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INSTRUCTION MANUAL

Microphone Sets

Includes

Ceramic Microphone Sets
Condenser Microphone Sets
1560-P42 Preamplifier
1560-P62 Power Supply
1972-9600 Preamplifier/Adaptor

B

GENERAL RADIO

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Handbook of Noise Measurement

This book, by Dr. A. P. G. Peterson and Ervin E. Gross, Jr., of the General Radio Engineering Staff covers thoroughly the subject of noise and vibration measurement. Copies are available from General Radio.

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1972-9600 Preamplifier/Adaptor

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Concord, Massachusetts, U.S.A. 01742
Form 1560-0102-B
November, 1972

WARRANTY

We warrant that this product is free from defects in material and workmanship and, properly used, will perform in full accordance with applicable specifications. If, within a period of ten years after original shipment, it is found, after examination by us or our authorized representative, not to meet this standard, it will be repaired or, at our option, replaced as follows:

- No charge for parts, labor or transportation during the first three months after original shipment;
- No charge for parts or labor during the fourth through the twelfth month after original shipment for a product returned to a GR service facility;
- No charge for parts during the second year after original shipment for a product returned to a GR service facility;
- During the third through the tenth year after original shipment, and as long thereafter as parts are available, we will maintain our repair capability and it will be available at our then prevailing schedule of charges for a product returned to a GR service facility.

This warranty shall not apply to any product or part thereof which has been subject to accident, negligence, alteration, abuse or misuse; nor to any parts or components that have given normal service. This warranty is expressly in lieu of and excludes all other warranties expressed or implied, including the warranties of merchantability and fitness for a particular purpose, and all other obligations or liabilities on our part, including liability for consequential damages resulting from product failure or other causes. No person, firm or corporation is authorized to assume for us any other liability in connection with the sale of any product.

Specifications

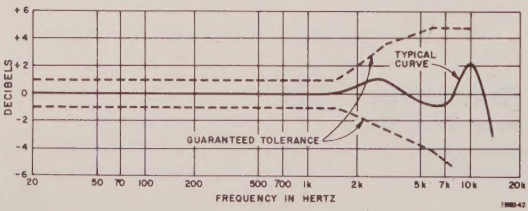
1560-P5 1-INCH CERAMIC MICROPHONE (CAT. NO. 1560-9605), 1-INCH CERAMIC MICROPHONE (CAT. NO. 1560-9570, INCLUDED IN SET 1560-9531), and 1560-P6 MICROPHONE ASSEMBLY (CAT. NO. 1560-9606).

Frequency Response: Microphone designed for flat random-incidence response. See curve. Below 20 Hz, typically flat ±1 dB down to 5 Hz re the 500-Hz level. Time constant of the pressure-equalizing leak is typically 0.08 s, with a corresponding 3-dB rolloff at 2 Hz.

Sensitivity: NOMINAL — −40 dB re 1 V/N/m²; −60 dB re 1 V/μbar. MINIMUM — −42 dB re 1 V/N/m²; −62 dB re 1 V/μbar.

Temperature Coefficient of Sensitivity: Approx −0.01 dB/°C.

Internal Impedance: CAPACITIVE — 1560-P5, 385 pF ± 15% at 23°C; 1560-P6, 405 pF ± 15% at 23°C. Temperature coefficient of capacitance — 2.2 pF/°C over range of 0 to 50°C.



Maximum Sound-Pressure Level: Distortion is less than 1% at 150 dB SPL. Minimum failure point of microphone is a positive pressure of 174 dB SPL, peak, and a negative pressure of 184 dB SPL, peak.

Environmental Effects: Microphone is not damaged by temperatures from −40 to +60°C and relative humidities of 0 to 100%. Exposure to a temperature of 95°C will cause a permanent loss in sensitivity of approximately 0.5 dB.

Terminals: The cartridge used for all three microphones is a 3-terminal device. For each microphone, the conversion to 2-terminal connection is made in the connector that identifies the 1560-9605, -9570, or -9606 microphone. The 1560-9605 and -9606 have 3-terminal audio connectors with #3 the signal terminal and #1 the low terminal, which is also the shell (ground). Terminal #2 is unused.

The 1560-9570 has a center-pin signal terminal and a .460-60 threaded-shell terminal, for direct connection to the 1560-P42 Preamplifier.

Mechanical Data: MICROPHONE CARTRIDGE ONLY — Diameter, 0.936 ± 002 in. (23.7 mm); length, 1.13 in. (29 mm); net wt. 1.15 oz (32.5 g); shipping wt., 1 lb (0.5 kg). 1560-P5 MICROPHONE COMPLETE — Diameter, 0.9375 in. (23.7 mm); length, 2.3125 in. (58.7 mm); net wt., 2 oz (60 g); shipping wt. 1 lb (0.5 kg). 1560-P6 MICROPHONE ASSEMBLY — Diameter, 15/16 in. (23.7 mm); length, 11 3/4 in. (298 mm); net wt. 10 oz (0.3 kg); shipping wt., 2 lb (0.9 kg). MICROPHONE SET 1560-9531 — All Microphone Sets are shipped in the same size carrying case, 10 x 2 1/8 x 7 1/4 in. (254 x 51 x 184 mm), width, height, and depth. Net wt (for each set, including case): approx 2.5 lb (1.1 kg). Shipping wt: 6 lb (2.8 kg).

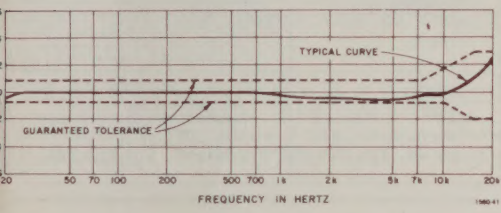
1972 ½-INCH CERAMIC MICROPHONE (INCLUDED IN SET 1560-9530)

Frequency Response: Designed for flat random-incidence response. See curve. Below 20 Hz, typically flat ±1 dB down to 5 Hz re the 1000-Hz level. The time constant of the pressure-equalizing leak is typically 0.08 s, with a corresponding 3-dB rolloff at 2 Hz.

Sensitivity: NOMINAL — −60 dB re 1 V/N/m²; −80 dB re 1 V/μbar. MINIMUM — −65 dB re 1 V/N/m²; −85 dB re 1 V/μbar.

Temperature Coefficient of Sensitivity: Approx −0.01 dB/°C.

Internal Impedance: CAPACITIVE — 395 pF ± 15% at 23°C. Temperature coefficient of capacitance is 2.2 pF/°C from 0 to 50°C.



Maximum Sound-Pressure Level: Distortion is less than 1% at 165 dB SPL. Minimum failure point of the microphone is a positive pressure of 180 dB SPL, peak, and a negative pressure of 190 dB SPL, peak.

Environmental Effects: Microphone is not damaged by temperatures from −40 to +60°C and relative humidities of 0 to 100%. Exposure to a temperature of 95°C will cause a permanent loss in sensitivity of approximately 0.5 dB.

Terminals: Microphone fits coaxial connector with .460-60-2B thread.

Mechanical Data: MICROPHONE CARTRIDGE ONLY — Diameter, 0.500 ± .0005 in. (12.7 mm); length, 0.783 ± .005 in. (19.9 mm); net wt, 0.5 oz (14 g); shipping wt, 0.5 lb (0.3 kg). COMPLETE MICROPHONE ASSEMBLY — Diameter, 0.5 in. (12.7 mm); length, 0.783 in. (19.9 mm); net wt, 0.5 oz (14 g); shipping wt, 0.5 lb (0.3 kg). MICROPHONE SET 1560-9530 — Refer to the MECHANICAL DATA for Microphone Set 1560-9531, above.

TYPE 1560-P42 PREAMPLIFIER

Gain: 1:1 or 10:1 (20 dB) ± 0.3 dB at 25°C, slide-switch selected; < 0.3 dB change from that at 25°C, from −30 to +65°C.

Frequency: Measured at 1 V rms output into open circuit with 600-ohm source, −30 to +55°C

Impedance: INPUT — capacitance, 6 pF; resistance ≈ 500 MΩ at low audio frequencies. Driven shield reduces input-capacitance loading for condenser microphones. OUTPUT — 15 Ω in series with 3.3 μF.

Output: Up to 11 V, pk-pk, into open circuit with 15-V supply at frequencies up to 10 kHz. Decreasing to 2 V, pk-pk, for 1:1 gain at 100 kHz. Up to 10 mA, rms, output (sine wave) with 1560-P62 (1560-9575) Power Supply.

Distortion: < 0.25% harmonic distortion at 1 kHz with 1 V, rms, into open-circuit load; < 1% at 10 kHz with 1 V, rms, into 0.1 μF (equivalent to 2000 ft of cable).

Polarizing Voltage: +200 V ±5% behind 300 MΩ (dc source resistance) slide-switch selected. Temperature coefficient approx + 0.1%/°C.

Noise: < 3.5 μV equivalent input noise with 390 pF source capacitance, C-weighted (10 kHz effective bandwidth).

Insert Terminals: Accepts insert calibration signal. Insert resistance, 10 Ω ±20%. Nominal loss be-

	3 Hz	5 Hz	20 Hz	100 kHz	300 kHz	500 kHz
1:1 GAIN	±3 dB	±1.0 dB	±0.25 dB	±1 dB		
10:1 GAIN	±3 dB	±1.5 dB	±0.3 dB	±2 dB		

tween connector and microphone terminals, < 0.5 dB. Maximum insert voltage, 1 V, rms.

Power: +15 to +25 V, dc; 1-2 mA idling with 200-V polarizing supply off, 3-5 mA with 200-V supply on.

Connectors: Input connector, 460-60 thread, for direct connection to ½-in. microphones and adaptors. Output (signal) connector, 3-terminal microphone connector, Switchcraft type A3 on 10-ft cable. Separate ground and shield, to reduce sensitivity to interference.

MECHANICAL DATA:

LENGTH		DIA		NET WT		SHIP WT	
in.	mm	in.	mm	lb	kg	lb	kg
6.5	165	0.5	13	1	0.5	3	1.4
less cable				with cable			

TYPE 1972-9600 PREAMPLIFIER/ADAPTOR

Gain: 0 dB +0 −0.25 at 1 kHz. FREQUENCY RESPONSE (at 1 V, rms, output into an open circuit, driven from a 600-Ω source):
±1 dB from 5 Hz to 100 kHz
±3 dB from 3 Hz to 500 kHz.

Input Impedance: Approx 3 pF in parallel with 1 GΩ at low audio frequencies.

Output Impedance: Less than 20 Ω in series with 6.8 μF.

Output: Maximum pk-pk output, at least 10 V at frequencies up to 100 kHz (open circuit); peak current available with 15-V supply, at least 1 mA.

Noise: < 2.5 μV equivalent input noise voltage with 390 pF source capacitance, C-weighted.

Distortion: <0.1% total harmonic distortion for frequencies up to 100 kHz at 1 V, rms, output into an open circuit, with +15-V supply.

Terminals: INPUT — .460-60 thread connects directly to 1972-9601 ½-in. microphone, 1560-9570 1-in. microphone, and 1560-9581 and 1560-9669 adaptors. OUTPUT — Switchcraft type A3M 3-pin audio connector; connects directly with GR analyzers.

Power: 9 to 25 V (1 mA at 9 V). Available from most GR analyzers or 1560-P62 Power Supply.

Mechanical Data: ¾ in. diameter, 3 7/16 in. long; net wt, 3 oz (0.1 kg); shipping wt, 1 lb (0.5 kg).

TYPE 1560-P62 POWER SUPPLY

Input: 100 to 125 V or 200 to 250 V, 50 to 60 Hz, switch-selected.

Output: +18 to +21 V, dc, at up to 15 mA, current limited, from two batteries; < 5 mV, rms, ripple in CHARGE-OPERATE mode.

Batteries: Two rechargeable 9.6-V NiCd batteries provide up to 225 mA-hours of operation at room temperature between charges; fully recharged in 14-16 hours. Operating temperature range, −15 to +50°C.

Operating Modes: CHARGE ONLY — Batteries charged from line at constant 21-24 mA. Preamplifier not connected. CHARGE AND OPERATE — Simultaneous line operation and battery charge. OPERATE ONLY — Preamplifier connected. Batteries protected from deep discharge. REMOTE: Line not connected. Preamplifier is connected remotely by applying +15 to +25 V at 0.3 mA. EXTERNAL CHARGING — Polarized 2-pin receptacle connects to charging terminals on 1561 Sound-Level Meter.

MECHANICAL DATA:

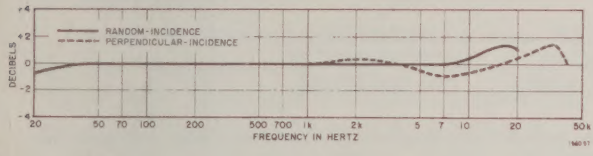
MODEL	WIDTH		HEIGHT		DEPTH		NET WEIGHT		SHIPPING WEIGHT	
	in.	mm	in.	mm	in.	mm	lbs	kg	lbs	kg
BENCH	8.500	216	3.844	97.5	5.500	138	3	1.4	5	2.3
RACK	19.000	483	3.844	97.5	6.020	154				

CONDENSER MICROPHONES

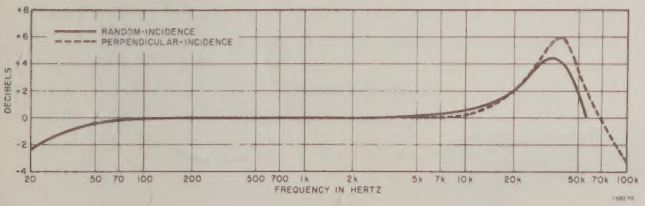
NOTE

The condenser microphones included in the following sets are manufactured by Brüel & Kjaer, Naerum, Denmark.

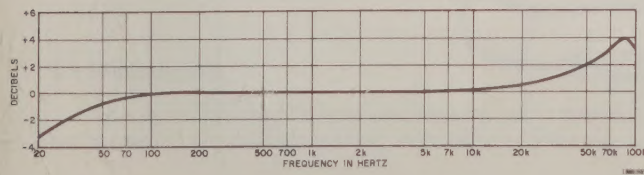
Type	SET 1560-9532	SET 1560-9533	SET 1560-9534	SET 1560-9535	SET 1560-9536
NOMINAL CARTRIDGE DIAMETER	1/2-INCH		1/4-INCH		1/8-INCH
FREQUENCY RESPONSE	Free field (0° incidence) 20 Hz to 40 kHz	Random incidence and Pressure 20 Hz to 20 kHz flat within ± 2 dB	Free-field (0° incidence) 30 Hz to 100 kHz	Random incidence and Pressure 30 Hz to 70 kHz flat within ± 2 dB	Random Incidence and Pressure 30 Hz to 140 kHz flat within ± 2 dB
CARTRIDGE OPEN – CIRCUIT SENSITIVITY	12.5 mV per N/m² –38 dB re. 1 V per N/m²		3.16 V per N/m² –50 dB re. 2 × 10⁻⁵ per N/m²	1.58 mV per N/m² –56 dB re. 1 V per N/m²	0.50 mV per N/m² –66 dB re. 1 V per N/m²
MAXIMUM DYNAMIC RANGE re. 2 × 10⁻⁵ N/m²	160 dB		174 dB	180 dB	184 dB
Harmonic Distortion	4 %		10 %	10 %	10 %
RESONANT FREQUENCY (90° phase angle)	25 kHz		75 kHz		
POLARIZATION VOLTAGE	200 V		200 V		
POLARIZED CARTRIDGE CAPACITY	18 pF		6.4 pF		3.5 pF
EQUIVALENT AIR VOLUME (at 1 atm)	0.01 cm³	0.01 cm³ *)	0.0005 cm³		< 0.0001 cm³
TEMPERATURE RANGE UP TO:	150°		120°C		
TEMPERATURE COEFFICIENT BETWEEN – 50°C and + 60°C	less than ± 0.01 dB/°C		less than ± 0.01 dB/°C		
INFLUENCE OF AMBIENT PRESSURE (increase in 250–Hz sensitivity for a 100 Hg decrease of pressure)	0.1 dB		0.1 dB	0.05 dB	0.01 dB
RELATIVE HUMIDITY INFLUENCE	Less than 0.1 dB (in the absence of condensation)				
DIMENSIONS OF CARTRIDGE without protecting grid:	Diameter: 12.7 mm (0.5")	Height: 11 mm (0.43")	Diameter: 6.35 mm (0.25")	Height: 9 mm (0.35")	Diameter: 3.175 mm (0.125") Height: 6.0 mm (0.240")
with protecting grid:	13.2 mm (0.52")	12.7 mm (0.5")	7.0 mm (0.275")	10.5 mm (0.41")	3.50 mm (0.140") 6.7 mm (0.268")



Typical response curves for the ¼-in. condenser Microphone Sets with protecting grid and preamplifier gain = X1. Random-incidence response for Set 1560-9533; perpendicular-incidence response for Set 1560-9532.



Typical response curves for the ¼-in. condenser Microphone Sets with protecting grid and preamplifier gain = X1. Random-incidence response for Set 1560-9535; perpendicular-incidence response for Set 1560-9534.



Typical random-incidence response for 1/8-in. condenser Microphone Set 1560-9536 with protecting grid, preamplifier gain = X1.

Figure 1-1. The GR Microphone Sets include a microphone cartridge, preamplifier, adaptors, and carrying case.

Introduction—Section 1

1.1 DESCRIPTION 1-1
1.2 ACCESSORIES SUPPLIED 1-5
1.3 ACCESSORIES AVAILABLE 1-6

1.1 DESCRIPTION.

1.1.1 General.

The General Radio Microphone Sets (Figure 1-1) consist of a microphone cartridge, a Type 1560-P42 Preamplifier, all adaptors necessary to mate the cartridge to the Preamplifier and to the GR 1562 Sound-Level Calibrator, and a carrying case for all components, including the Preamplifier. Complete details of the use of these items are given in this book. Also described is the GR 1560-P62 Power Supply, which is required with the Preamplifier when it is used with sound-measuring instruments that do not include a source of power to operate the Preamplifier. Additional available accessories, such as the 1560-9600 Preamplifier/Adaptor, 1560-9580 Tripod, microphone windscreens, and miscellaneous adaptors, are also included. Details of the 1560-P6 Microphone Assembly are also given in this book.

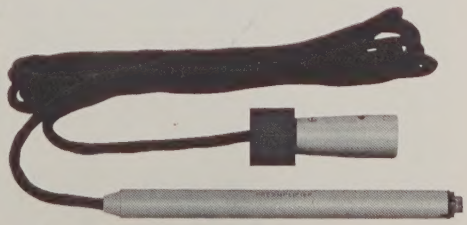
The ceramic sets are available with a 1/2-in. or 1-in. ceramic microphone cartridge. Condenser sets can be supplied with any of five condenser microphones. Table 1-1 gives a complete listing of the available sets.

1.1.2 Microphones.

Ceramic microphones are noted for their ruggedness, stability and reliability. Their low impedance results in low preamplifier noise and high sensitivity, and contributes to good performance under conditions of relatively high humidity. Complete details of the GR ceramic microphones are given in Section 3.

Condenser microphones feature smooth high-frequency responses, with good sensitivity. They are available in various sizes. However, an external polarizing voltage is required. The condenser microphones are fully described in Section 3.

Figure 1-2. Type 1560-P42 Preamplifier.



1.1.3 Preamplifier.

The Type 1560-P42 Preamplifier (Figure 1-2) is specifically designed to amplify the output from a capacitive source, such as a ceramic or condenser microphone, or a

Table 1-1

TYPICAL CHARACTERISTICS FOR MICROPHONE SETS

GR Catalog Number (sets)	Microphone Type	Response Characteristic	Open-Circuit Sensitivity -dB re 1 V/N/m^2	Cartridge Capacitance pF	System Sensitivity re 1 V/N/m^2 Gain = X1 dB	Lower Frequency limit Hz	Upper Frequency limit kHz	Typical Dynamic Range Noise Level to SPL for Maximum Output (sine wave) dB A-weighting	dB C-weighting
1560-9530	GR 1/2 in. Ceramic	Flat Random Incidence	-60	395	-60	5	20	42-165	44-165
1560-9531	GR 1 in. Ceramic	Flat Random Incidence	-40	380	-40	5	12.5	22-145	24-145
1560-9532	B&K 4133 1/2 in. Condenser	Flat Perpendicular Incidence	-38	18	-40	20	40	31-145	41-145
1560-9533	B&K 4134 1/2 in. Condenser	Flat Pressure (random incidence)	-38	18	-40	20	20	31-145	41-145
1560-9534	B&K 4135 1/4 in. Condenser	Flat Perpendicular Incidence	-50	6.4	-54	50	100	49-158	60-158
1560-9535	B&K 4136 1/4 in. Condenser	Flat Pressure (random incidence)	-56	6.4	-60	50	70	55-165	65-165
1560-9536	B&K 4138 1/8 in. Condenser	Flat Pressure (random incidence)	-66	3.5	-73	70	140	69-178	79-178

piezoelectric vibration pickup. It also provides step-down impedance so that long cables can be used between the microphone/preamplifier combination and GR sound-level meters or analyzers without signal loss. It can be used to increase the sensitivity and input impedance of amplifiers, analyzers, counters, recorders, and similar instruments; it can also serve as a general-purpose audio preamplifier for resistive or capacitive sources.

The Preamplifier incorporates a 3-stage amplifier with a low-noise FET input stage and class AB output stage. Excellent stability is obtained with ac and dc feedback. A slide switch offers a choice of X1 or X10 gain, controlled by ac feedback. A self-contained oscillator/rectifier circuit supplies the polarizing voltage (+200 V) for condenser microphones that can be switched off when ceramic microphones are used. The oscillator operates at approximately 60 kHz.

The Preamplifier is housed in a stainless-steel tube 6 1/2 in. long with a 1/2-in. diameter. A 10-ft output cable is permanently attached. Details of the Preamplifier are given in Section 4.

1.1.4 Power Supply.

Power for the Preamplifier (15-25 V dc, 15 mA maximum) can be obtained from most GR sound-level meters and analyzers, as noted in Table 1-2. The 1560-P62 shielded, battery-powered supply is available for use with other instruments or where more supply current is required for driving large signals through long cables. The 1560-P62 includes 2 nickel-cadmium batteries with charging circuitry. Load-current is limited to prevent damage to the Preamplifier in the event of shorted lines. Provision has been made to turn the -P62 power on or off from a remote analyzer.

For the description and use of the 1560-P62 Power Supply, refer to Section 5 of this book.

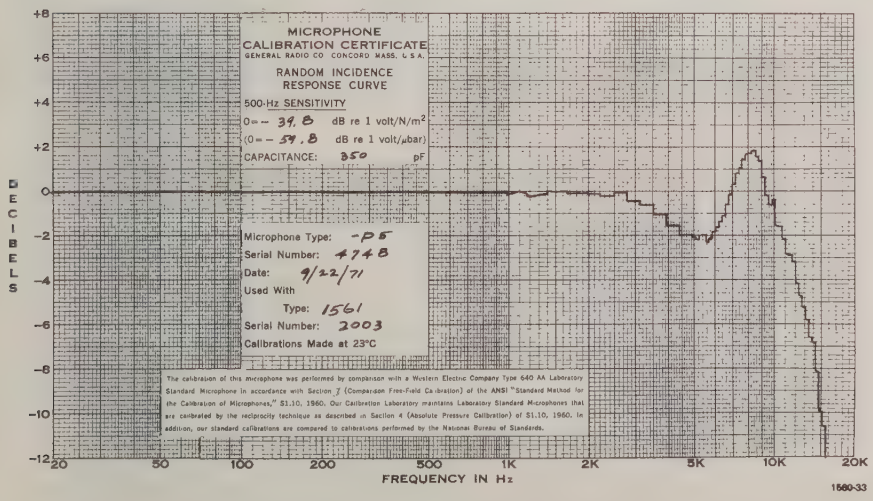


Figure 1-3. The microphone response curve is included with each GR Microphone Set.

Table 1-2

PREAMPLIFIER POWER FROM GR ACOUSTICAL INSTRUMENTS

Type No.	Instrument	Open-Circuit Voltage	Source	Source Resistance	Max. Available Current To -P42*	Notes
1525	Data Recorder	20 V	20 V Reg.	2.5 kΩ	4 mA	
1551-C	Sound-Level Meter	Requires Power Supply				Use 1560-P62 Power Supply
1553	Vibration Meter	Requires Power Supply				Use 1560-P62 Power Supply
1558	Octave-Band Analyzer		2–9.6-V NiCd	1 kΩ	2.6-6 mA	
1560-P62	Power Supply		2–9.6-V NiCd	Current Limited 15 mA	15 mA	
1561-A, R	Precision Sound-Level Meter		2–9.6-V NiCd 3–9.0-V CZn	1.3 kΩ	0.85-8.3 mA	Not recommended for use with condenser microphones
1564	Sound and Vibration Analyzer		1–19.2-V NiCd	240 Ω	3-5 mA	
1565	Sound-Level Meter	Requires Power Supply				Use 1560-P96 Adaptor and 1560-P62 Power Supply
1566	Multi-Channel Amplifier	16 V ±5%	16 V Reg.	100 Ω	10 mA	
1568**	Wave Analyzer (1% Bandwidth)	17.6 V min	2–9.6-V NiCd	820 Ω	3-5 mA	
1569	Automatic Level Regulator	25 V ±5%	25 V Reg	Current Limited Less than 1 Ω	25 mA	
1900	Wave Analyzer	Requires Power Supply				Use 1560-P62 Power Supply
1921***	Real-Time Analyzer	19 V ±5%	19 V Reg	300 Ω	10 mA	
1925***	Multifilter	19 V ±5%	19 V Reg	300 Ω	10 mA	
1934	Walsh-Healey Noise-Exposure Meter	15 V ±5%	15 V Reg	< 2 Ω	20 mA	
1523	Level Recorder	16 V ±5%	16 V Reg.	100 Ω	10 mA	

*Indicates range for high- and low-voltage batteries.

**For instruments shipped before March, 1972, R_{source} = 2 kΩ and max. avail. current = 1.3–3 mA; not recommended for use with long cables or condenser microphones.

***For instruments shipped before March, 1972, $V_{open\ circuit}$ = 15 V and max. avail. current = 3 mA; not recommended for use with long cables or condenser microphones.

Note 1: For reliable performance, load current multiplied by source resistance (total supply and cable resistance) must not exceed the difference between the supply source voltage and + 15 V supply rating of the 1560-P42. In other words, $E_{source} - (I_{load} \times R_{source + cable})$ must be > 15 V.

Note 2: Refer to Figure 4-2 to relate these maximum currents to the permissible signal levels in output cables. The quiescent current of the Preamplifier (1-2 mA for ceramic microphones and 3-5 mA for condenser microphones) must be subtracted from the supply current to determine the signal current available to drive long cables.

1.2 ACCESSORIES SUPPLIED.

1.2.1 General.

The Microphone Sets include a Microphone Calibration Certificate, showing the response curve for the microphone (Figure 1-3) and a Data Card giving the open-circuit sensitivity and capacitance of the cartridge, as well as the sensitivity of the complete system.

The adaptors supplied with the various sets are described below.

The Preamplifier is shipped with the input connector protected by a plastic insulator cap.

A small stainless-steel clamp is provided, to serve as a hanger for the Preamplifier. The clamp is shipped attached to the output cable, ready for use. It can be placed at any desired point along the cable. The hole in the clamp is used to hang the microphone and Preamplifier (by the cable), for mounting, such as "free" suspension in an anechoic chamber.

A carrying case, P/N 1560-0427, with cutouts for the microphone, Preamplifier and adaptors, is also supplied with each set (see Figure 1-1).

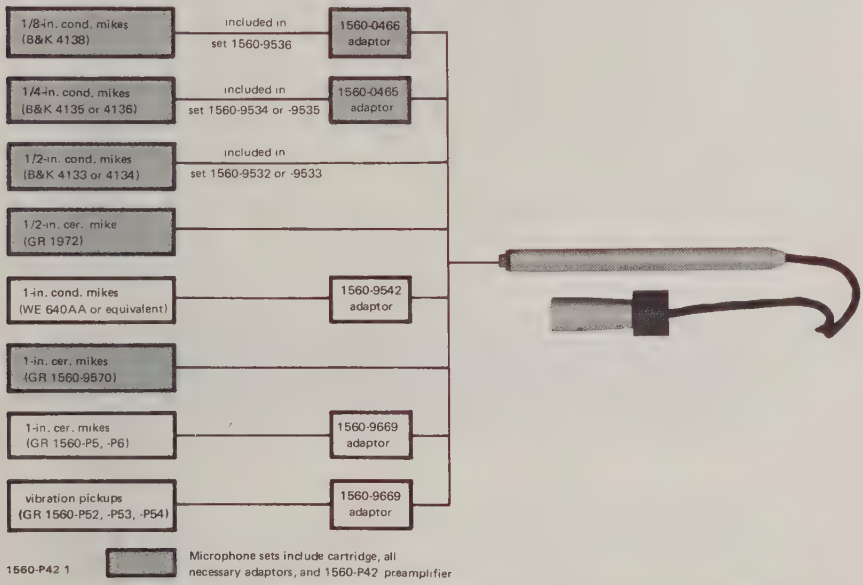

1/8-in. cond. mikes (B&K 4138)
included in set 1560-9536
1560-0466 adaptor
1/4-in. cond. mikes (B&K 4135 or 4136)
included in set 1560-9534 or -9535
1560-0465 adaptor
1/2-in. cond. mikes (B&K 4133 or 4134)
included in set 1560-9532 or -9533
1/2-in. cer. mike (GR 1972)
1-in. cond. mikes (WE 640AA or equivalent)
1560-9542 adaptor
1-in. cer. mikes (GR 1560-9570)
1-in. cer. mikes (GR 1560-P5, -P6)
1560-9669 adaptor
vibration pickups (GR 1560-P52, -P53, -P54)
1560-9669 adaptor
1560-P42 1
Microphone sets include cartridge, all necessary adaptors, and 1560-P42 preamplifier

Figure 1-4. Adaptors supplied or available to connect the microphone to the Preamplifier.

1.2.2 Adaptors.

As shown in Figure 1-4, the 1/2-in. microphones connect directly to the input of the Preamplifier. The 1560-9570 1-in. ceramic microphone is supplied as a cartridge with a built-in adaptor for direct connection to the -P42. The smaller condenser-microphone sets (1/4- and 1/8-in.) include the necessary adaptors (not sold separately) to mate with the Preamplifier input connector.

Adaptors are supplied with each Microphone Set, when necessary, to fit the Type 1562 Sound-Level Calibrator to the microphone in the set. Adaptors for the 1-in. and

the ½-in. ceramic microphones are supplied with the Calibrator. The Calibrator is an accurate, self-contained device for checking the calibration of sound-measuring instruments or systems. It supplies a known sound-pressure level at five different frequencies, and is ideal for calibrating a Microphone Set with its measuring instrument.

1.3 ACCESSORIES AVAILABLE.

1.3.1 Extension Cables.

Ceramic microphones are self-generating devices and do not require direct connection of the Preamplifier to the cartridge. But, whenever possible, this should be done. The direct connection minimizes the loss in sensitivity due to the shunt capacitance added by any cable between the microphone and the measuring instrument. A direct connection also minimizes the noise generated in cables and connectors by immediately reducing the impedance to a low value, for transmission of the signal over long cables.

Occasionally, however, it is desirable to place the ceramic microphone some distance from the preamplifier or the measuring instrument. A 25-ft extension cable, P/N 1560-9673, and a 100-ft cable, P/N 1560-9982, are available for this purpose. These *low-noise* coaxial cables are fitted with 3-terminal, shielded, Switchcraft type A3 connectors, female on one end and male on the other. A 1560-9669 adaptor is required to connect the cable to the Preamplifier input. The cable has a capacitance of approximately 22 pF/ft, which introduces a loss between the microphone and the preamplifier. This dB loss should be added to all readings when a cable is used. The loss involved for each length of this cable with the 1/2-in. or the 1-in. ceramic microphone is given in Table 1-3. Figure 6-2 gives the loss for other lengths of cable. Whenever possible, make an accurate determination of this loss with the Type 1562 Sound-Level Calibrator.

Connection to the Switchcraft A3 connector for the 1-in. microphone is made by use of the 1560-P5 Microphone or the cartridge plus the 1560-3040 adaptor (available from the GR Service Dept). For the ½-in. ceramic microphone, this connection is made by the 1972/9600 Preamplifier/Adaptor. Refer to Section 6 for details of its use as an adaptor.

Table 1-3

EXTENSION-CABLE LOSSES

Microphone	Cable Length	Cable P/N	Correction (dB to be added)
1972-9601 (1/2-in. ceramic)	25 ft	1560-9673	7.0
	100 ft	1560-9982	15.5
1560-9605 (1-in. ceramic) (1560-P5)	25 ft	1560-9673	7.2
	100 ft	1560-9982	15.9

Cables for use between the Preamplifier output and the analyzing instrument are also available. They mate directly with the input and output connectors of the 1560-P62 Power Supply and the input connector of most GR analyzers, sound-level

meters, and recorders. Made of shielded, 3-wire cable, they are terminated in Switchcraft type 3A, 3-pin connectors on each end (one male, one female), and are available in two lengths:

25 ft long, P/N 1560-9666

100 ft long, P/N 1560-9667.

One lead of the cable carries the power voltage to the Preamplifier.

The -P42 Preamplifier is supplied with an attached 10-ft cable, to which the longer cables can be directly connected.

Refer to para. 4.4 for the use of cables at the output of the Preamplifier.

1.3.2 Adaptors Available.

(Refer, also, to para. 1.3.3.)

The following adaptors are available separately, for use with the Microphone Sets:

Adaptor, P/N 1560-9581, mates the GR 1-in. 1560-2131 Ceramic Cartridge (refer to para. 3.6) with the -P42 Preamplifier input connector. This adaptor is supplied with the 1560-9570 Microphone and the 1560-9531 Microphone Set.

Adaptor, P/N 1560-9669, mates the Preamplifier input connector with a Switchcraft, 3-pin, microphone connector, for use with GR vibration pickups, the 1560-P5 or -P6 Ceramic Microphone, or 1560-9673 or -9982 Extension Cables.

Adaptor, P/N 1560-9542 (Figure 1-5), provides proper mechanical and acoustical coupling between a standard 1-in. condenser microphone (such as the Western Electric model 640AA or the Tokyo Riko Laboratories Co., Ltd., model MR103) and the input to the Preamplifier. This adaptor preserves the 1-in. diameter of the microphone for a distance adequate for precision acoustic measurements (refer to para. 4.2.1).

Coupler/Adaptor Set, P/N 1560-9561, adapts 1/2-, 1/4-, and 1/8-in. condenser microphones to the 1562 Sound-Level Calibrator.

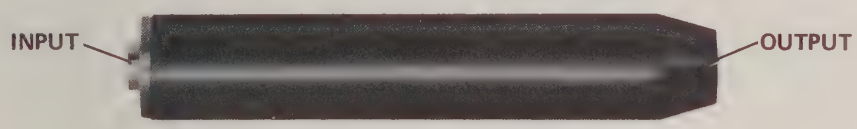


Figure 1-5. The 1560-9542 Adaptor mates standard 1-in. condenser microphones to the -P42 Preamplifier.

1.3.3 Type 1972-9600 Preamplifier/Adaptor.

This inexpensive Preamplifier/Adaptor (refer to Section 6) is used to mate GR 1/2-in. and 1-in. ceramic microphones (1972-9601 and 1560-9570, respectively) to cables connecting to the input of a measuring instrument. The Preamplifier provides unity gain and sufficient current to drive more than 50 feet of cable. The internal preamplifier can be bypassed to allow the microphone terminals to be mated directly to a standard Switchcraft connector.

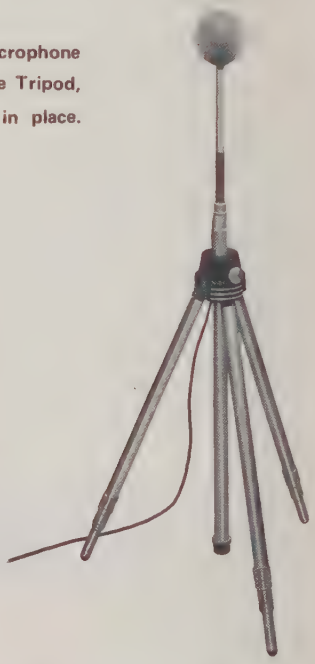
Complete details of the use of the 1972-9600 Preamplifier/Adaptor are given in Section 6 of this manual.

1.3.4 Microphone Windscreens.

Microphone windscreens (Figure 1-5) are used to reduce the effects of ambient wind noise. Wind flowing across the surface of the microphone generates low-frequency noise, which can lead to erroneous measurements. The windscreen also protects the microphone from accumulations of vapor and dust in the work environment.

This accessory fits snugly over the microphone. It is made of reticulated polyurethane foam and can be conveniently removed and washed, or replaced, if it becomes soiled. This is in addition to the obvious advantage of attenuating up to 20 dB of ambient wind noises, such as might emanate from a fan blowing cooling air or outdoor winds across the site being monitored.

Figure 1-6. The Preamplifier and microphone mounted on the Tripod, with the windscreen in place.



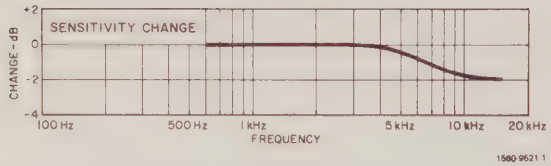


Figure 1-7. Changes in sensitivity of 1-in. microphone caused by use of a windscreen.

Any attenuation of monitored noise resulting from use of the windscreen occurs over only a portion of the frequency spectrum being monitored. The loss of system sensitivity occasioned by use of the windscreen is 0 dB to 3 kHz, ≈ 0.5 dB to 5 kHz, and ≈ 2 dB to 12 kHz (see Figure 1-7).

The windscreens are available in packs of four, P/N 1560-9522 to fit 1/2-in. microphones and P/N 1560-9521 for 1-in. microphones.

1.3.5 Tripod.

The 1560-9580 Tripod (Figure 1-6) is designed to accept a variety of sound equipment, including the 1/2-in. and 1-in. microphones, the 1560-P42 Preamplifier, and the 1560-9600 Preamplifier/Adaptor. The 1-in. ceramic microphone can be mounted on the Tripod either with or without the Preamplifier. The ½-in. ceramic

microphone can be mounted on the Tripod by using the 1972-9600 Preamplifier/Adaptor or the 1560-P42 Preamplifier. All condenser microphones require the -P42 Preamplifier to mount them on the Tripod.

The Tripod includes a locking nut, two Allen-head setscrews (250-28, 188), and an Allen wrench for these setscrews. It is shipped with the swivel top and two mounting sleeves. To mount them on the Tripod, screw the threaded end (A, Figure 1-8) of the swivel top onto the center rod. The sleeves are locked to the swivel top by 2 setscrews (B and C). Use the inner (1/2-in. diameter) sleeve to support the 1560-P42 Preamplifier. The mounting procedure is given below.

Adjusting the Tripod. The height of the tripod mount can be adjusted by raising or lowering either the center rod or the legs, or both.

CAUTION

Be sure the 9 knurled locking nuts in the legs of the Tripod are tightened securely before the Tripod is used.

The swivel top can be rotated through 360° by rotating the center post of the Tripod. The top can be tilted to a horizontal position in one direction. The tilt in the opposite direction is limited to 70° from the horizontal, giving the proper mounting angle to approximate random-incidence response from a sound source in a free field.

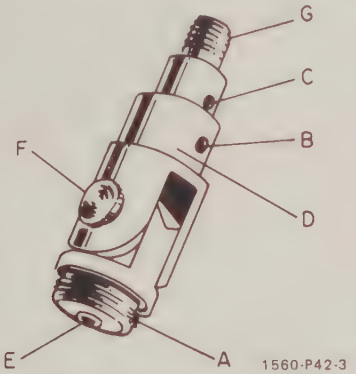


Figure 1-8. Location of parts of the Tripod swivel top.

Tension on the swivel (F, Figure 1-8) can be adjusted in the following manner:

a. Separate the entire swivel top from the Tripod by unscrewing it at the threaded end (A).

b. Adjust the setscrew (E) in the threaded end to give the desired tension on the swivel.

c. Screw the swivel top back in place on the Tripod.

Mounting the Preamplifier. To mount the Preamplifier on the Tripod:

a. With the Allen wrench provided, turn the setscrew (B, Figure 1-8) in the ¾-in. step (D) of the swivel top in a cw direction until the head of the setscrew is below the surface of the shoulder.

b. Remove the ¾-in. sleeve.

c. Slide the Preamplifier into the top end of the 1/2-in. sleeve, with the cable end down. Allow room for the cable to extend out through the slot in the sleeve.

CAUTION

Do not allow the edges of the slot to pierce the cable insulation.

Mounting a Microphone. When mounting the 1-in. ceramic microphones without a preamplifier, use the large-diameter sleeve. Simply slide the microphone into the top end of the sleeve, with the attached cable extending down and out through the slot. With the ½-in. ceramic microphone with the 1972-9600 Preamplifier/Adaptor, use the large-diameter sleeve. For all microphones with the -P42 Preamplifier, use the small-diameter sleeve.

Mounting Other Instruments. The 1/4-20 threaded stud (G, Figure 1-8) fits all GR sound-level meters except the Type 1551-C, which requires a 3/8—16 to 1/4—20 adaptor (available in most camera stores). The knurled locking nut (supplied) is used to lock the instrument in place on the stud. Use the following procedure:

a. Remove any sleeves or adaptors from the swivel top.

b. Screw the locking nut onto the threaded stud (G) as far as it will go.

c. Screw the instrument to be mounted on the Tripod onto the threaded stud. (This is more easily accomplished by turning the center rod of the Tripod into the instrument.)

d. Turn the locking nut tight against the instrument, to lock it in place.

Sound Fields—Section 2

2.1 FREE FIELDS 2-1
2.2 DIFFUSE (REVERBERANT) FIELDS 2-1
2.3 SEMI-REVERBERANT FIELDS 2-1
2.4 PRESSURE FIELDS 2-1
2.5 SOUND INCIDENCE 2-2

2.1 FREE FIELDS.

A sound field is said to be a free field if it is uniform, free from boundaries, and is undisturbed by other sources of sound. In practice, it is a field in which the effects of the boundaries are negligible over the region of interest. At any given point in a free field, the sound wave can be approximated by plain sound waves that have a given direction of propagation; the flow of sound energy is in one direction only.

A free field can be simulated in an enclosed environment by applying acoustic absorbing materials, usually in the form of wedges, to the boundaries. These anechoic (echo-free) chambers can be built to make free-field measurements possible over much of the acoustic frequency range. The field in an anechoic chamber is a free field above the lower cut-off frequency of the absorbing wedges. (The cut-off frequency is the point at which the wavelength of the sound wave is equal to four times the depth of treatment.)

Another approximation to a free field occurs outdoors, in particular, in open spaces, well above the ground.

2.2 DIFFUSE (REVERBERANT) FIELDS.

A diffuse or reverberant sound field is one in which the time average of the mean square sound pressure is everywhere the same and the flow of energy in all directions is equally probable. The sound is reflected from the boundary surfaces; there is no particular direction of propagation to the sound wave. At any given point in the diffuse field, sound is arriving equally from all directions (random incidence).

2.3 SEMI-REVERBERANT FIELDS.

A semi-reverberant field is one in which sound energy is both reflected and absorbed. The flow of sound energy is in more than one direction. Much of the energy is truly from a diffused field; however, there are components of the field that have a definable direction of propagation from the noise source. The semi-reverberant field is encountered in the majority of noise-measurement situations.

2.4 PRESSURE FIELDS.

A pressure field is one in which the instantaneous pressure is everywhere uniform. There is no direction of propagation. The pressure field exists primarily in cavities

(commonly called couplers), where the maximum dimension of the cavity is less than 1/6 of the wavelength of the sound. A pressure field is used in couplers for the calibration of microphones and earphones.

2.5 SOUND INCIDENCE.

2.5.1 Free-Field Sensitivity (Response)*

The free-field response of a microphone is the open-circuit output voltage caused by the free-field sound pressure in the *undisturbed* sound field; i.e., the pressure that existed at the location of the microphone prior to the introduction of the microphone into the sound field. For free-field sensitivity, the angle between the direction of sound propagation and the plane of the microphone diaphragm, as well as the frequency, must be specified.

2.5.2 Free-Field Response.

The free-field response of a microphone is the voltage output divided by the pressure that existed at the location of the microphone prior to the introduction of the microphone into the sound field. Free-field responses are typed according to the angle between the direction of sound propagation and the plane of the microphone diaphragm.

Perpendicular-Incidence Response (0°). With this type of response, the direction of sound propagation is perpendicular to the plane of the diaphragm (at an angle of 0° to the normal of the diaphragm). The sound wave is moving in one direction only, directly into the microphone. This condition occurs only in a free-field environment (or, under very special circumstances, in certain semi-reverberant environments).

Grazing-Incidence Response (90°). In this case, the direction of sound propagation is parallel to the plane of the microphone diaphragm (at 90° to the normal of the diaphragm). The sound wave can approach the microphone from any side, but its direction must be parallel to the diaphragm surface. This type of incidence occurs mostly in free-field environments.

The directions of sound propagation for perpendicular- and grazing-incidence responses are shown in Figure 2-1.

2.5.3 Random-Incidence Response.

The random-incidence response of a microphone is its voltage output when subjected to a diffuse sound field. The flow of energy in any direction is almost equally probable. Because of nearby reflecting surfaces, this is the most common type of sound field.

2.5.4 Pressure Sensitivity.

The pressure sensitivity of a microphone is the voltage output when the diaphragm is excited with a pressure that is uniform over the entire surface of the diaphragm. The accuracy and repeatability of a pressure calibration are more easily controlled than with free-field methods. For this reason, the standard calibrations determined by the National Bureau of Standards are pressure-sensitivity (pressure-response) calibrations.

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*Technically, "sensitivity" and "response" have the same meaning. However, "sensitivity" is commonly used for a single-frequency statement, and "response" is used when the sensitivity as a function of frequency is intended.

2.5.5 Diffraction.

The physical size of the microphone causes diffraction of sound waves when the wavelength is not appreciably greater than the dimensions of the microphone, and gives rise to differences between the responses defined above. At low frequencies, all responses of a microphone are the same and the microphone is truly an omnidirectional receiver of sound. The various responses start to diverge at the frequency at which the diameter of the microphone is equal to approximately 1/10 of the wavelength of the sound. The curves of Figure 2-2 show typical response characteristics for a microphone of 1-in. diameter. To a first approximation, the differences between the curves would hold for any measurement microphone of this size. For the 1/2-in. microphone, the frequency scale would be approximately double that for the 1-in. microphone. For a 1/4-in. microphone, the frequency scale would be increased by approximately a factor of 4, and for a 1/8-in. microphone, by a factor of 8.

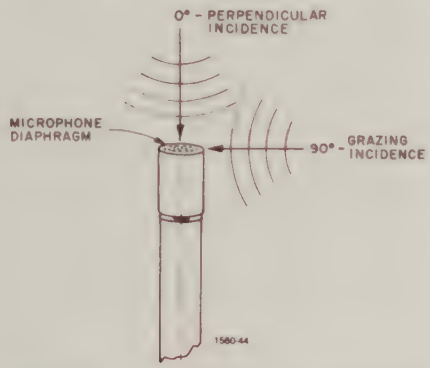

Figure 2-1. Direction of sound propagation for perpendicular- and grazing-incidence responses.

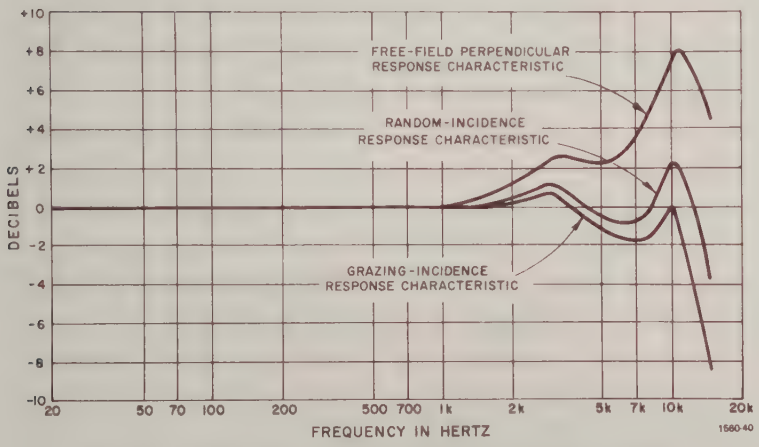

Figure 2-2. Typical response characteristics for the 1-in. microphone.

Characteristics of Microphones
Section 3

3.1 TRANSDUCERS 3-1
3.2 CLASSIFICATIONS OF SOUND-MEASUREMENT MICROPHONES . . .3-1
3.3 EQUIVALENT CIRCUIT 3-2
3.4 MICROPHONE SELECTION 3-3
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3.1 TRANSDUCERS.

A transducer transforms energy from one form to another. In the case of microphones, it changes the pressure variation of an acoustic wave into an electrical signal proportional to that pressure variation. Vibration pickups, specifically accelerometers, transform the motion of a vibrating body into an electrical signal proportional to their acceleration.

3.2 CLASSIFICATIONS OF SOUND-MEASUREMENT MICROPHONES.

3.2.1 General.

Sound-measurement microphones are divided into two main classes: condenser and ceramic microphones. Others, such as dynamic and controlled-reluctance types, lack the frequency-response control and stability necessary to make them usable as measurement microphones. The most important requirements for a measurement microphone are reliability and stability. Stated simply, this means that, between calibrations, accurate measurements can be made with a measurement microphone, and the conditions normally encountered in making sound measurements will not have a detrimental effect on the microphone or its calibration. Ceramic and condenser microphones meet these two requirements.

3.2.2 Condenser Microphones.

In this type of microphone, the variation of an electrical capacitance is used to control an electrical signal.

The original high-quality measurement microphone was a condenser type, developed by Bell Telephone Laboratories. This microphone, known as the Western Electric 640AA, remains the standard of measurement and calibration.*

*E. C. Wente, "A Condenser Transmitter as a Uniformly Sensitive Instrument for the Absolute Measurement of Sound Intensity," *Physical Review*, Vol 10, 1917, pp 39-63.
M. S. Hawley, "The Condenser Microphone as an Acoustic Standard," *Bell Laboratories Record*, Vol 33, No 1, January 1955, pp 6-10.

The advantages of a condenser microphone are: smooth frequency-response characteristic, good sensitivity, and wide availability in various sizes and styles. However, condenser microphones require a polarizing voltage, to bias them properly. Also, their relatively high output impedance makes them more susceptible to problems caused by high humidity. The high impedance also results in greater preamplifier noise.

3.2.3 Ceramic Microphones.

A more recent type is the ceramic microphone which uses a piezoelectric ceramic (lead-titanate, lead-zirconate) as the voltage-generating element. The piezoelectric material produces a voltage when it is stressed. A diaphragm fastened to the ceramic transfers the sound-pressure variations into a corresponding varying force that bends the ceramic element.

This is a self-generating device (it requires no polarizing voltage). It has excellent stability and reliability, and its internal impedance is an order of magnitude lower than that of the condenser microphones, with an equivalent usable energy output. Also, it is not affected by most environmental conditions.

Ceramic microphones are good general-purpose devices, suitable for most measurement applications.

3.3 EQUIVALENT CIRCUIT.

The equivalent circuit for both the condenser and ceramic microphones is shown in Figure 3-1. The voltage source (e) is in series with the characteristic capacitance of the microphone cartridge (C_m). The value of the source voltage is equal to M, the microphone sensitivity, times the pressure (P) exciting the diaphragm of the microphone. The sensitivity ***level***,

$$R = 20 \log_{10} \left(\frac{M}{M_R} \right) \text{ in dB}$$

where M_R is the reference sensitivity and must be stated. Useful relationships to remember are that the value of e is 1 mV when M = −40 dB re 1 V/N/m^2 (or −60 dB re 1 V/μbar), and P = 74 dB SPL or 1 μbar (or 1 dyne/cm^2). At the threshold of hearing of 20 μN/m^2, a −40 dB microphone produces a voltage output of 0.2 μV.

The voltage delivered to the measuring instrument is dependent upon the instrument input impedance.

If the microphone is connected directly to a long cable (capacitive load) without a preamplifier, the long cable merely reduces the sensitivity of the microphone by

$$E_{in} = \frac{C_m}{C_{in} + C_m} \times e$$

where C_{in} = input capacitance of the instrument and the cable;

E_{in} = instrument input voltage.

The cable does not affect the frequency response because the microphone and cable capacitances change the impedance in the same proportion with changing frequency.

A preamplifier is usually used between the microphone and measuring instrument, to provide impedance transformation (very high to very low). This results in no loss in

microphone sensitivity and, hence, no cable correction. In addition, preamplifiers usually provide some gain (20 dB), thus permitting the instrument to measure to lower levels.

The high input resistance of the preamplifier makes possible good low-frequency response with a high source impedance. The low input capacitance of the preamplifier minimizes loading of the microphone, thereby maintaining good sensitivity

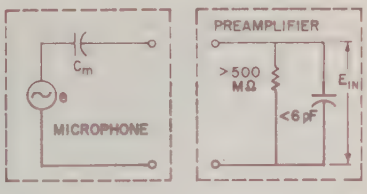

Figure 3-1. Equivalent circuits for a microphone and preamplifier.

3.4 MICROPHONE SELECTION.

3.4.1 General.

Measurement microphones are designed to have either a flat pressure-response characteristic, a flat random-incidence response characteristic, or a flat free-field perpendicular-response characteristic. For the measurement of noise, in general, a microphone with a flat random-incidence response should be selected. The American National Standard for sound-level meters is based on a flat random-incidence response. The International Specification for precision sound-level meters permits other responses, but it stipulates that the supplier must give calculations and corrections for deriving the random-incidence response. As stated above, the random-incidence response of a microphone is its voltage output when subjected to a diffuse sound field. The fields encountered in noise measurements are not truly diffuse. However, this is the closest approximation for nearly all indoor and most outdoor applications. An exception is aircraft flyover or automotive passby noise. In these applications, the noise signature of the vehicle is best measured with a microphone having a flat grazing-incidence response. For a vehicle passby on the ground, the microphone is placed with its diaphragm facing upward, so that the angle of incidence from the sound source to the microphone remains constant at grazing incidence. For aircraft flyover, the angle of incidence is kept constant by mounting the microphone with its axis parallel to the ground and perpendicular to the surface described by the arc of the flyover.

As shown in Figure 2-2, the difference between the grazing-incidence or pressure response and the random-incidence response of a 1-in. microphone is small, so that either a flat random-incidence microphone or a flat pressure microphone gives a good approximation to a flat grazing incidence. Sound-power measurements in a diffuse room are an ideal application for a microphone with a flat random-incidence response.

If one is making sound-pressure (sound-power) measurements of a device in an anechoic chamber, the sound wave is radiating outward from the source and there are no reflections. For this application, use a microphone with flat perpendicular-incidence response, with the microphone pointed directly at the sound source.

If one is measuring the response in a coupler of small diameter compared with the wave length, use a microphone with a flat pressure response. Likewise, for

measurement of the pressures at the ear drum, a microphone having a flat pressure response should be used.

In general, select the largest microphone that has adequate frequency response for the intended application.

Figure 3-2 is a plot of the response of various 1-in. microphones.

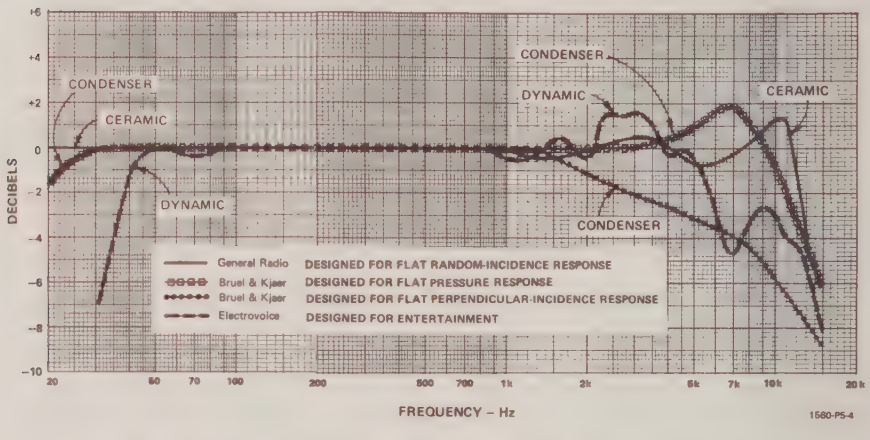

Figure 3-2. Random-incidence response of various types of microphones.

3.4.2 Sensitivity.

Until recently, the sensitivity level of a microphone was referenced to 1 V/μbar. The new American National Standard has changed the reference to 1 V/N/m^2, and Sensitivity Level = x dB re 1 V/N/m^2. Because 1 N/m^2 = 10 μbar, the new reference is merely 20 dB higher than the old reference.

Say we have a microphone with a sensitivity level of −40 dB re 1 V/N/m^2. What output voltage will it generate for a sound pressure of 1 N/m^2?

A sound pressure of 1 N/m^2 is a sound pressure level (SPL) of 94 dB, where

$$\text{SPL} = 20 \log_{10} \left(\frac{1 \text{ N/m}^2}{20\ \mu\text{N/m}^2} \right) \text{dB}$$

$$= 20 \log_{10} \left(\frac{1}{.00002} \right) = 94 \text{ dB}.$$

Thus, a microphone with a sensitivity level of −40 dB re 1 V/N/m^2 will generate an output voltage of 10 mV for a sound pressure level of 94 dB.

By remembering this simple relationship, one can calculate the output voltage of

any microphone, with any sensitivity, for any sound pressure. This is particularly useful for determining signal-to-noise ratio relationships.

For example, for the same sound-pressure level, a −40 dB microphone generates 3.16 times the voltage generated by a −50 dB microphone ($20 \log_{10} 3.16 = 10$ dB). A −50 dB microphone will generate 3.16 mV for a 94-dB SPL, and if we subject it to a 114-dB sound-pressure level, the voltage generated is 20 dB higher or 31.6 mV.

3.4.3 Dynamic Range.

The low end of the dynamic range of a microphone/preamplifier system is determined by the self noise of the preamplifier when its input is terminated by the capacitance of the microphone. The noise level of the preamplifier is a function of the microphone capacitance. As a result, the low end of the dynamic range is limited by both preamplifier self noise and microphone sensitivity.

The upper end of the dynamic range is usually limited by the output-voltage amplitude or the output-current level at which the preamplifier no longer amplifies linearly. The maximum voltage swing is a function of the power-supply or battery voltage for the preamplifier and the current level is a function of the length of cable attached to the preamplifier output (cable reactance). Microphone sensitivity is also a limitation here, as the more sensitive the microphone, the more voltage it generates for a given SPL.

The range for the GR 1/2-in. ceramic microphone with the 1560-P42 Preamplifier is approximately 42 to 165 dB SPL. For the 1-in. ceramic microphone, the range is 22 to 145 dB SPL.

The dynamic ranges of GR microphones are given in Table 1-1.

3.5 MINIMIZING DIFFRACTION.

The occasion often arises when one wishes to use a microphone with a smaller diameter, to provide a more omnidirectional characteristic or to enable one to select the response to be used. Another important consideration, however, is the size of all the material intercepting the sound field. This includes the microphone, preamplifier, and their supports. Figure 3-3 shows the free-field perpendicular-incidence response characteristic of a 1/2-in. microphone mounted in line on a 1/2-in. rod. This rod, in turn, connects to a 3/4-in. rod at a point 1 in. from the diaphragm of the microphone. Note that variations of approximately ±1 dB occur because of the diffraction produced by the larger-diameter rod. A good rule to follow is to maintain the diameter of the microphone for a distance equal to 5 times the larger diffracting diameter. Beyond the 5-diameters point, a gradual taper to the larger diameter should be employed. In the figure, the controlling diameter is the 3/4-in. support rod. Therefore, the 1-in. distance from the diaphragm to the larger rod should be increased to approximately 4 inches.

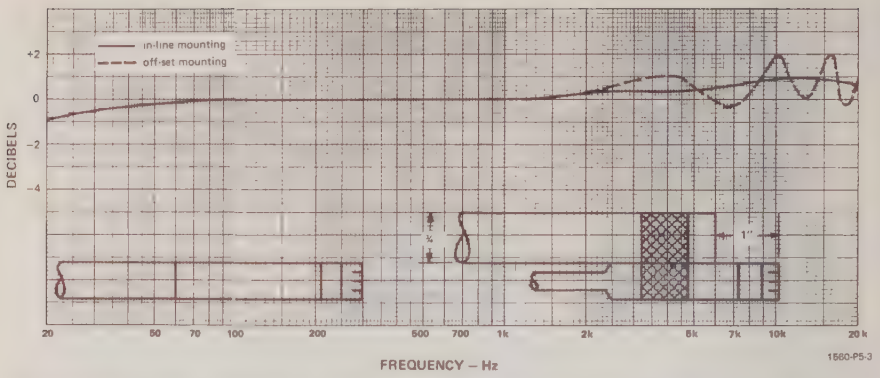

Figure 3-3. Free-field perpendicular-incidence response characteristic of a ½-in. microphone (see text).

3.6 GR CERAMIC MICROPHONES.

3.6.1 General.

The GR ceramic microphones are offered in 1/2-in. and 1-in. sizes (refer to Table 1-1).

The 1560-2131 Microphone Cartridge is used in the GR 1-in. ceramic microphones, including the 1560-9570 and 1560-P5 Microphones and the 1560-P6 Microphone Assembly (see Figure 3-4). In this cartridge, neither lead is connected to the shell, making it possible to eliminate ground loops when the Cartridge is used in critical applications.

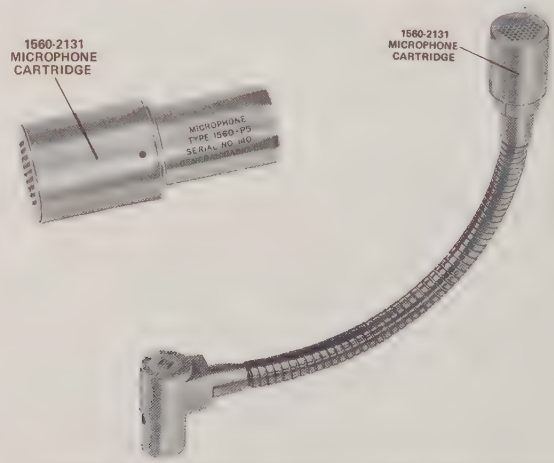

Figure 3-4. The 1560-P5 Microphone (left) and the 1560-P6 Microphone Assembly.

The Cartridge is a high-quality, measurement-type unit, suitable for use with many high-input-impedance preamplifiers, decade amplifiers, or sensitive voltmeters. The input impedance required for response down to 20 Hz is 20 MΩ or higher.

The shell of the 1-in. Cartridge and one lead are connected together through the base or adaptor. The red dot on the Cartridge identifies the signal terminal, which is

also the positive-potential terminal when a positive pressure pulse is applied to the diaphragm of the Cartridge.

In the 1560-P5 Microphone, the Cartridge is fixed to a 3-pin, male, microphone connector. The 1560-P6 Microphone Assembly is supplied with the Cartridge connected to a 12-in. gooseneck, with a 3-pin male microphone connector on the other end. To connect the 1560-P5 Microphone or -P6 Assembly to the -P42 Preamplifier, the 1560-9669 adaptor is required; or the Cartridge can be removed from the base and a 1560-9581 adaptor can be used to adapt the Cartridge to the 0.460-60-2B thread of the 1560-P42 Preamplifier.

3.6.2 Calibration.

Both the 1/2-in. and 1-in. GR ceramic microphones are designed for a flat random-incidence response (refer to Specifications). When there is a possibility that the sound wave may have some directivity, the microphone should be tipped at an angle of 70° to the direction of the sound source. This gives a flat response characteristic for any direct radiated sound. The 70°-incidence response closely approximates the random-incidence response.

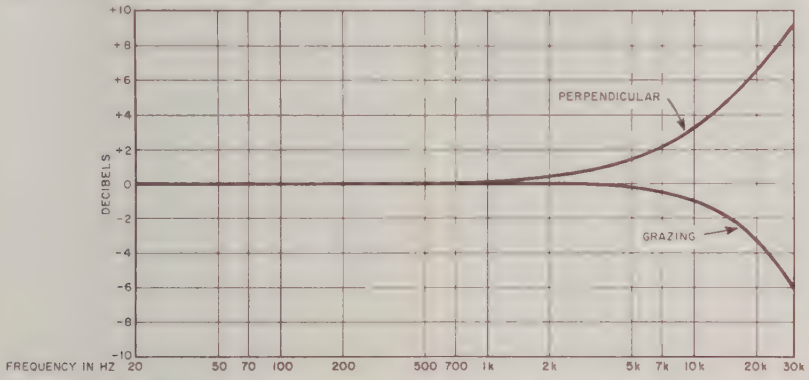

Figure 3-5. Corrections to be added to the random-incidence response of the ½-in. microphone to obtain the perpendicular- and grazing-incidence responses.

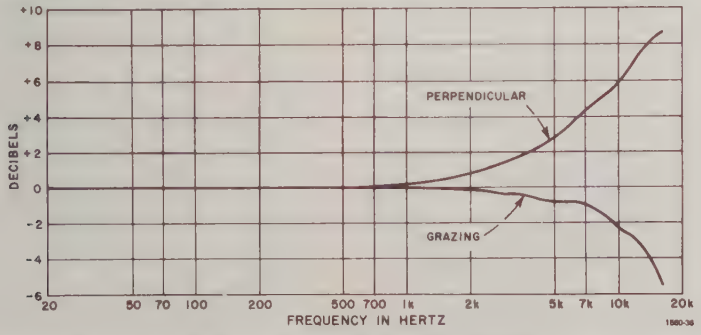

Figure 3-6. Corrections to be added to the random-incidence response of the 1-in. microphone to obtain the perpendicular- and grazing-incidence responses.

The curves given with the Specifications show the random-incidence response characteristics for the two microphones. Figures 3-5 and 3-6 give the corrections to be

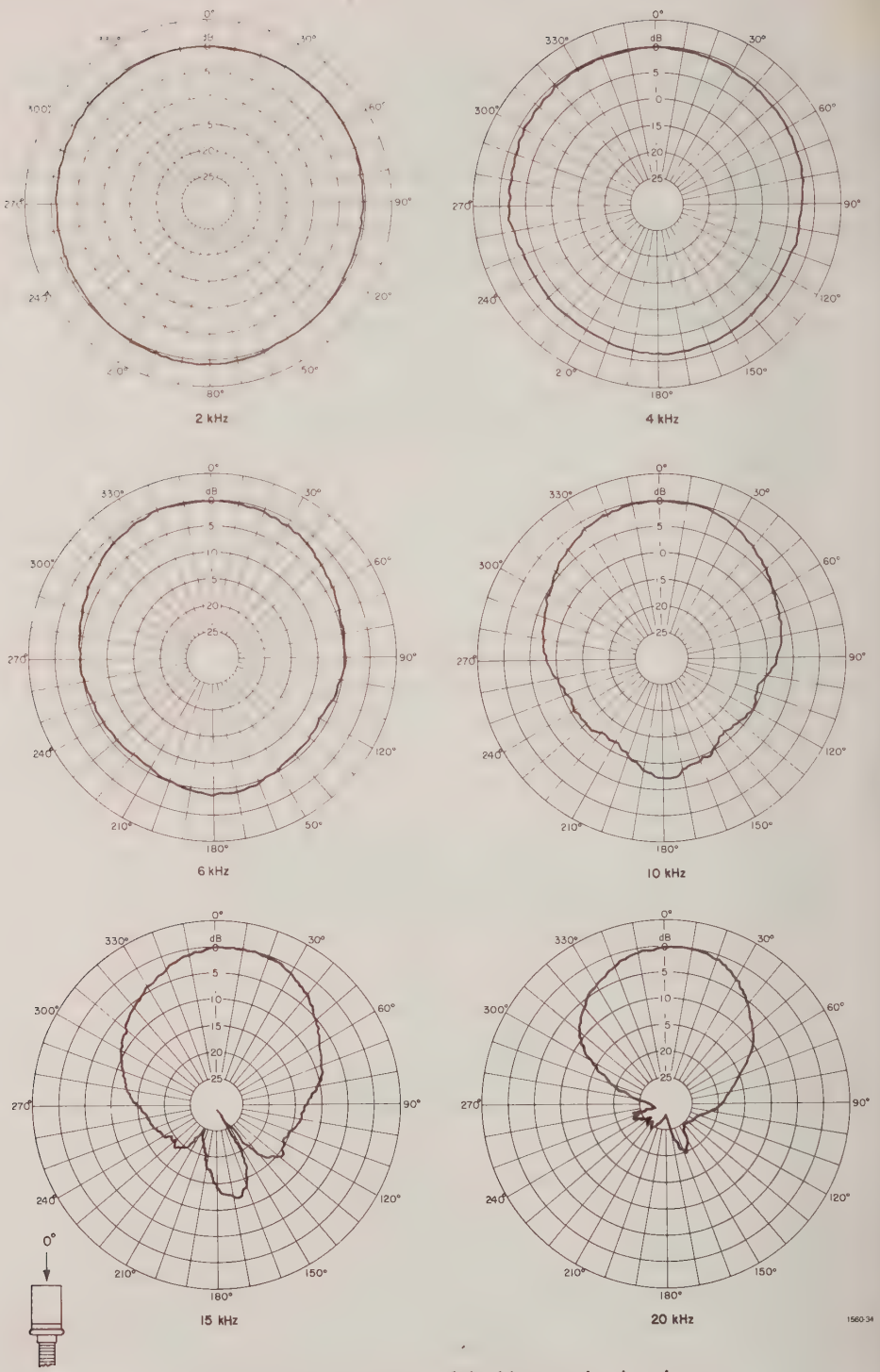

Figure 3-7. Directional patterns of the 1-in. ceramic microphones.

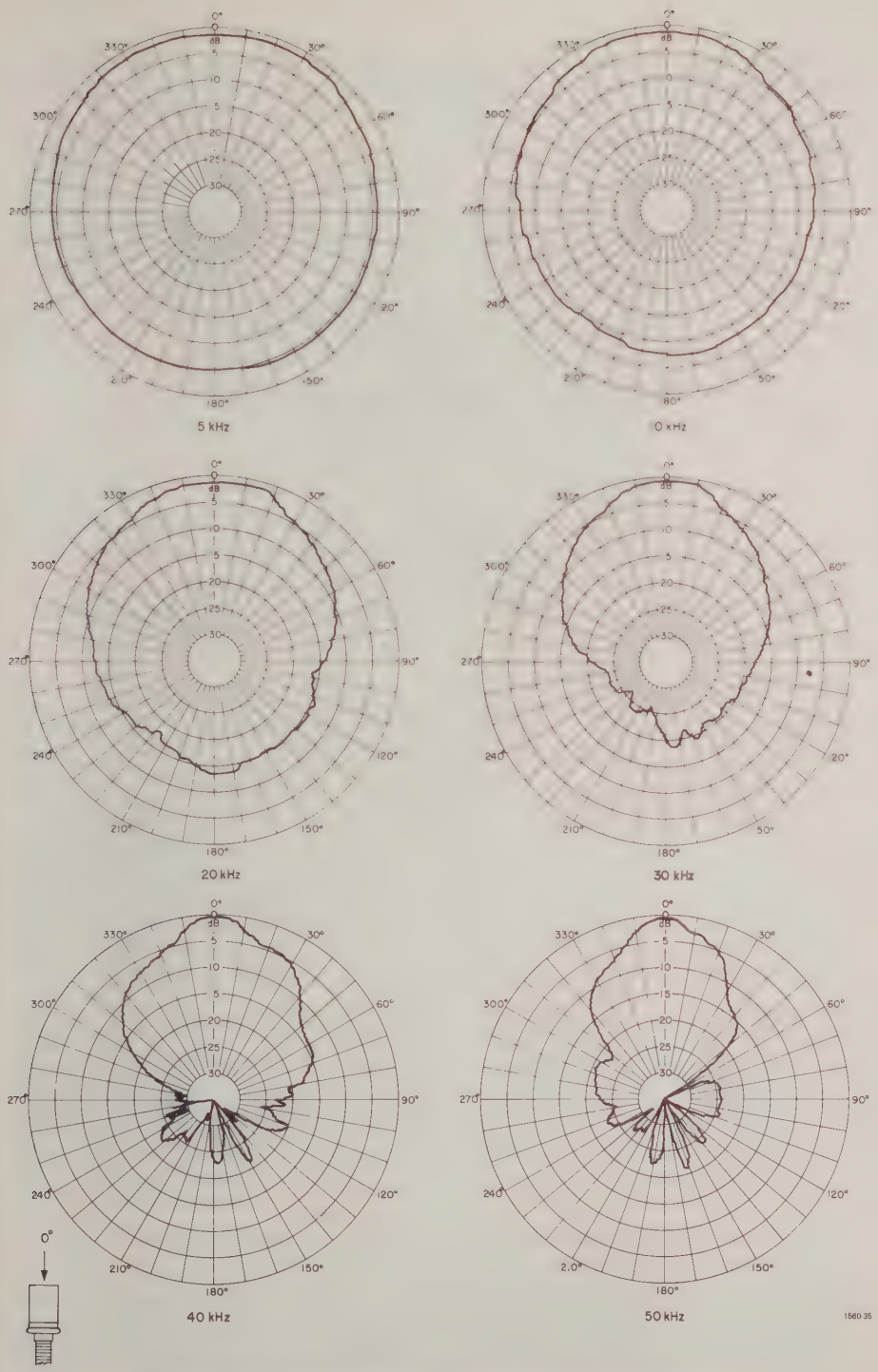

Figure 3-8. Directional patterns of the ½-in. ceramic microphones.

added (algebraically) to the random-incidence responses, to obtain the perpendicular-incidence and grazing-incidence responses for the microphones.

3.6.3 Mechanical Description.

The diameter of the 1-in. Microphone is 0.936 ± .002 in. This diameter is identical to the Western Electric 640AA; thus the microphone can be used interchangeably with the 640AA in couplers designed for earphone and hearing-aid calibrations, etc. For this use, the equivalent volume of the 1-in. microphone is 0.5 cc; the equivalent volume of the 640AA is 0.7 cc with the grid off and 0.3 cc with the grid on. For practical purposes, the GR 1-in ceramic microphone is totally interchangeable with the Western Electric 640AA.

The diameter of the 1972 ½-in. microphone is 0.500 in; its equivalent volume is 0.15 cc.

3.6.4 Diffraction Characteristics.

Diffraction of the sound waves by the 1-in ceramic microphone starts at approximately 1 kHz. Below this frequency, it is truly omni-directional. Figure 3-7 shows the directional characteristics of the microphone to 20 kHz.

Figure 3-8 shows the directivity curves for the 1972 ½-in. microphone. This size microphone is approximately omni-directional (±3 dB) to 5 kHz.

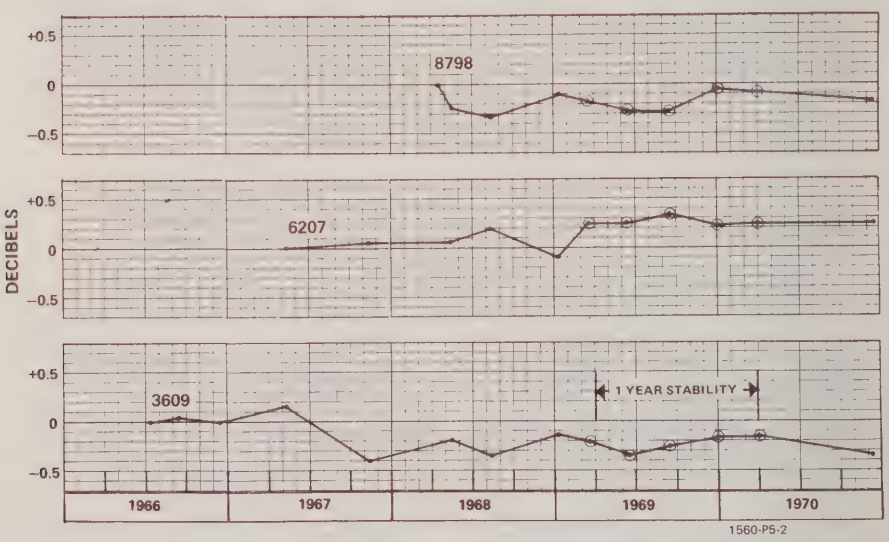

Figure 3-9. Stability record for several sample microphones.

3.6.5 Stability.

Work with the GR ceramic microphones over the years has proved that they have excellent short- and long-term stability. Figure 3-9 shows the record for several sample microphones over various periods of time, up to 4 1/2 years. Stability tests, started in

1966-1969, immediately upon production of the microphones, show a small initial drift (up to 0.3 dB), after which the microphones stabilize as shown in the figure. Other evidence indicates that this drift is completed after 5 days. The normal manufacturing and testing cycle at GR guarantees that this initial drift is completed before the microphones are calibrated for sale.

The microphones were also evaluated for stability according to the procedures outlined in the American National Standard Institute (ANSI) S1.12-1967 for Laboratory Standard Microphones. Table 3-1 shows the average results for several Type 1560 1-in. ceramic Microphones.

Table 3-1

STABILITY RATING OF 1560-P5 MICROPHONES

PER PROCEDURE OUTLINED IN ANSI S1.12 - 1967

	SHORT-TERM STABILITY, 5-DAY PERIOD		LONG-TERM STABILITY, 1-YEAR PERIOD	
	$\|m\|$ dB/day	S dB	$\|m\|$ dB/yr.	S dB
STANDARD REQUIREMENT	.04	0.1	0.4	0.15
TYPE 1560-P5	.0075	.032	.085	.07

WHERE
$|m|$ = MAGNITUDE OF THE SLOPE OF CURVE OF SENSITIVITY VS TIME
S = STANDARD DEVIATION OF RESIDUALS

1560-P5-6

3.6.6 Temperature Effects.

The GR ceramic microphones are stable up to 60°C (140°F). If the microphones are used above this temperature, there is a permanent loss of 1 dB in sensitivity (following the initial exposure) up to 100°C (212°F). If the microphones are to be used above 60°C, they should be heat treated previously for several hours at the highest temperature of operation. They should then be allowed to cool to room temperature and, after 24 hours, the sensitivity should be measured. The microphones are thus stabilized for operation at any temperature up to that at which they were heat-treated. However, use of the microphones above 60°C is not recommended and when so used the warranty is no longer valid.

3.6.7 Humidity Effects.

The impedance of the ceramic microphones is approximately an order-of-magnitude lower than that of the condenser microphones of equivalent size and no polarizing voltage is required; therefore, they are much less susceptible to the effects of humidity. Under most normal conditions of humidity, the microphones are totally unaffected. However, under conditions of severe humidity with condensation of

moisture, the leakage resistance will decrease, as shown in Figure 3-10, causing a low frequency roll-off. This roll off is determined by the characteristic capacitance of the microphone and the value of the leakage resistance. Humidity and moisture tests were made on a 1560 1-in. ceramic microphone according to MIL-STD-202C, Method 106-B1 (see Figure 3-11), after which the leakage resistance had dropped to approximately 300 kΩ, making the microphone unusable below 1000 Hz. Within 24 hrs., under normal room conditions, the microphone had recovered.

3.6.8 Ruggedness.

The 1-in. ceramic microphone was subjected to several environmental tests, to evaluate its ruggedness. The tests are shown in Figure 3-11. The net result of the entire evaluation procedure was a negligible change in sensitivity and frequency response.

3.6.9 Pressure-Equalization Air Leak.

A controlled air leak is built into the terminal plate of the GR ceramic microphones, to equalize the static pressure on the back and front of the diaphragm when the ambient pressure changes. At very low frequencies, the air leak equalizes the sound pressure on each side of the diaphragm, thus causing a roll-off in the low-frequency response. The air leak and the total enclosed volume of the cartridge combine to form a high-pass filter whose cutoff frequency is determined by the time constant of the pressure equalization. For the GR ceramic microphones, the time constant is .08 s, which results in a low-frequency cutoff (response down 3 dB) of 2 Hz. The microphone can withstand a pressure step of approximately 0.1 atmosphere (1.5 psi, 3 in. of Hg, or 10^4 N/m^2). For a ramp pressure-change with time, the rate of change of pressure is 1 atmosphere/s. At sea level, this amounts to an initial rate of climb of 30,000 ft/s.

3.6.10 Vibration Sensitivity.

If the ½-in. ceramic microphone is subjected to an acceleration of 1 g at 20 and 100 Hz with the force perpendicular to the plane of the diaphragm, the microphone will generate an equivalent sound-pressure level of 98 dB. For the 1-in. ceramic microphone, the level is 100 dB.

3.7 CONDENSER MICROPHONES.

3.7.1 General.

> NOTE
> The condenser microphones described in this book are manufactured by Bruel & Kjaer, DK2850, Naerum, Denmark.

Microphone Sets are available with a choice of five condenser microphones: a 1/2-in., 1/4-in., or 1/8-in. microphone with a flat random-incidence response, or a 1/2-in. or 1/4-in. microphone with a flat perpendicular response. The accessories, supplied and available with these sets, are described in Section 1. The advantages and

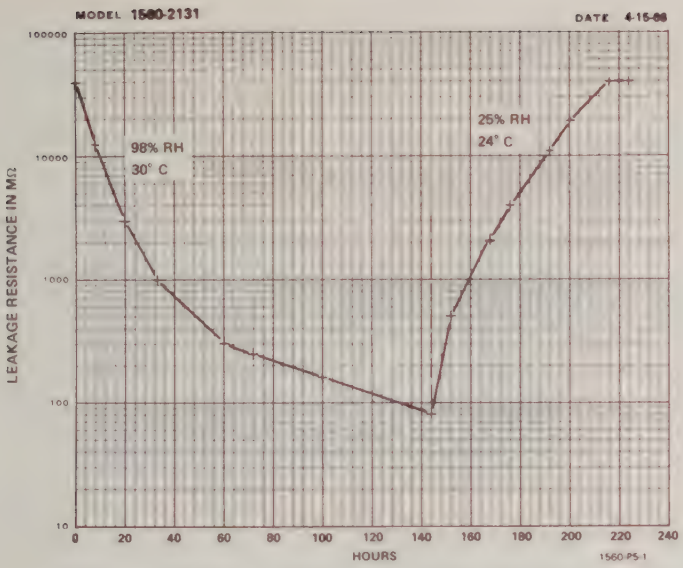

Figure 3-10. Change in leakage resistance with humidity changes.

1560-P5 EVALUATIONS

VIBRATION SENSITIVITY:
1 g ACCELERATION AT 20 & 100 Hz ≅ 100 dB SPL

TEMPERATURE RANGE:
OPERATES AT 85°C & –55°C

THERMAL SHOCK:
–55°C FOR ½ HR; TRANSFER WITHIN 5 MIN TO +85°C FOR ½ HR.
5 CYCLES

MECHANICAL SHOCK PER MIL 202 C METHOD 202.
50 g HALF SINE SHOCK (2 AXES)

VIBRATION PER MIL 202 C METHOD 204:
60 MILS P TO P OR 10 g 10-500 Hz 15 MIN SWEEP 12 TIMES, (3 AXES)

HUMIDITY & MOISTURE PER MIL 202 C METHOD 106-B-1:

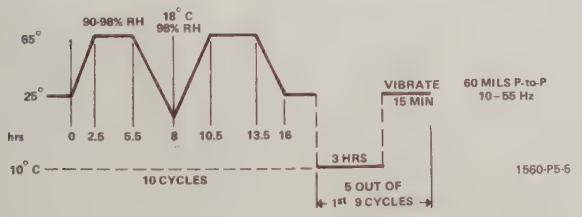

Figure 3-11. Results of environmental tests according to MIL-STD-202C, Method 106-B1.

disadvantages of the condenser microphones are noted in Section 2 A comparison of the random-incidence responses for typical condenser microphones with those of other types is shown in Figure 3-2.

The 200-V polarizing voltage required for the condenser microphones is supplied by the 1560-P42 Preamplifier (refer to Section 4). Each Microphone Set is complete with the required adaptor to mate the microphone with the Preamplifier.

A protecting grid is also supplied with each condenser microphone. The influence of the protecting grid should be considered for free-field measurements. The microphones are calibrated with the grid installed. The increase in pressure with the grid in place is considerably higher at high frequencies, and, in this area, the effect of the grid depends somewhat on how tight it is screwed onto the cartridge.

To obtain the frequency response of a cartridge at a particular incidence, the free-field corrections are to be added to the individual pressure response (supplied with microphone). The random-incidence (diffuse-field) corrections for the microphone are included in Figures 3-12 and 3-13 for the ½- and ¼-in. microphones.

3.7.2 Calibration.

The condenser-microphone sets are furnished with either a perpendicular-incidence or a pressure response. The free-field corrections for other incidences can be obtained from Figures 3-12, 3-13, and 3-14.

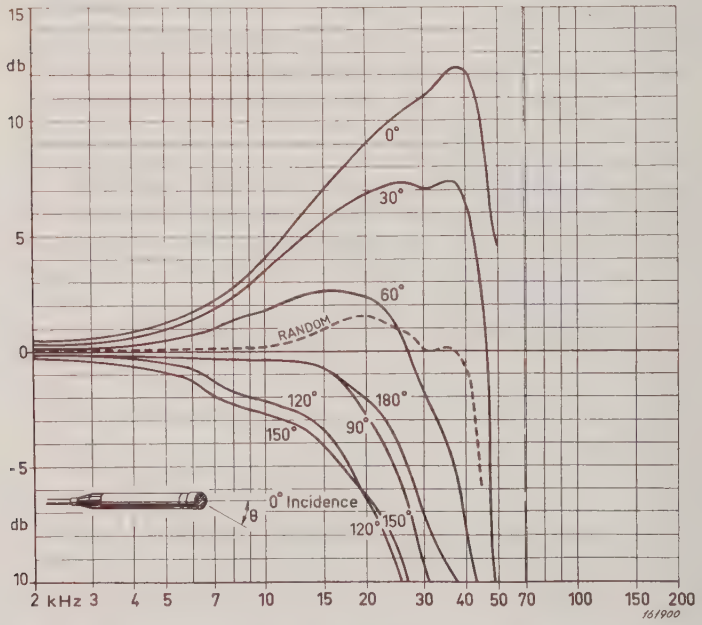

Figure 3-12. Free-field corrections to be applied to the pressure response of the 1/2-in. condenser microphones with the protecting grid. (Art, courtesy of Brüel & Kjaer.)

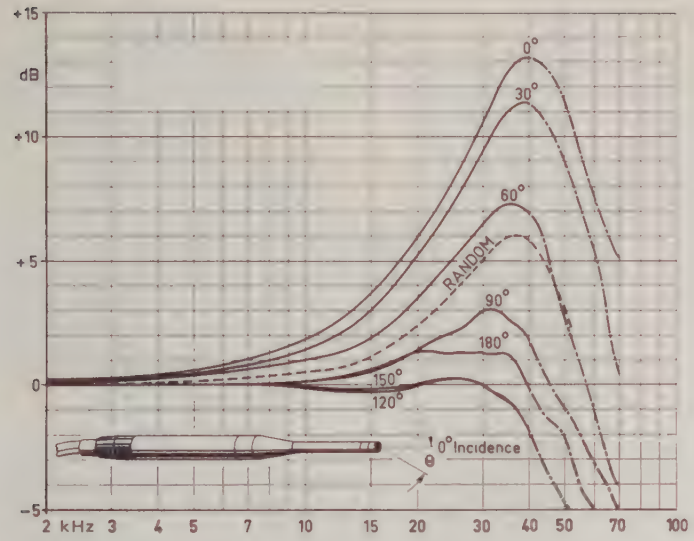

Figure 3-13. Free-field corrections to be applied to the pressure response of the 1/4-in. condenser microphones with the protecting grid. (Art, courtesy of Brüel & Kjaer.)

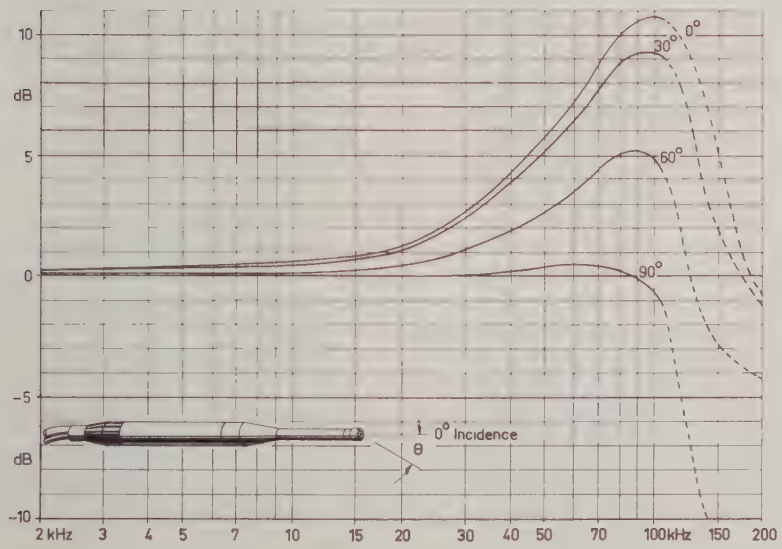

Figure 3-14. Free-field corrections to be applied to the pressure response of the 1/8-in. condenser microphones with the protecting grid. (Art, courtesy of Brüel & Kjaer.)

3.7.3 Directional Patterns.

Typical directional patterns for the condenser microphones at various frequencies are shown in Figures 3-15 to 3-17. The microphones are omnidirectional within 3 dB to approximately 8 kHz for the 1/2-in., 20 kHz for the 1/4-in., and 60 kHz for the 1/8-in. microphones.

3.7.4 Dynamic Range.

The limits of the dynamic range are set by the noise level of the microphone-and-preamplifier combination for the low limit and by the total harmonic distortion for the upper limit. The highest sound-pressure level that should be applied to the 1/2-in. microphones for 4% total distortion is 160 dB (safety limit is 174 dB). The ¼-in. microphone will produce approximately 10% distortion at 174 dB, and the 1/8-in. microphone 10% at 184 dB. These values are for the microphone alone. Refer to Table 1-1 for system performance.

3.7.5 Temperature Effects.

A typical temperature-sensitivity curve for the ½-in. condenser microphone is shown in Figure 3-18. The cartridges can tolerate a continuous temperature of 150°C and up to 250°C for about 10 minutes with no damage, but a permanent change in the characteristics will occur. Also, cable insulation may be affected at much lower temperatures. The preamplifier may be damaged at temperatures above 85°C.

3.7.6 Ambient-Pressure Effects.

The sensitivity of the microphone will change less than −0.1% for an increase of 10% in ambient pressure. The frequency response will be affected mainly at higher frequencies (because of the change in mechanical damping). The influence of varying altitude is very small; a rate of climb of 33,000 ft/s at ground level affects the sensitivity less than 1 dB.

The effect of changes in ambient pressure for the ½-in. microphone is shown in Figure 3-19.

3.7.7 Humidity Effects.

The relative humidity, when condensation is not present, has practically no effect on the sensitivity of the microphone. Any moisture formed between the diaphragm and the electrode of the microphone will have evaporated in a very few minutes after resumption of normal ambient conditions.

3.8 POLARIZING-VOLTAGE EFFECTS.

For simple analyses, the sensitivity of the condenser microphones may be taken to be directly proportional to the polarizing voltage. Figure 3-20 shows this relationship. The limits of the 1560-P42 polarizing supply are shown, and a curve of polarizing supply voltage vs temperature of the Preamplifier is given. Note that the effect of the polarizing voltage is included in the system-sensitivity value supplied with each condenser-microphone set.

The shape of the upper portion of the frequency-response curve is altered slightly as the polarizing voltage changes, but this alteration is negligible for variations encountered in the 1560-P42 Preamplifier.

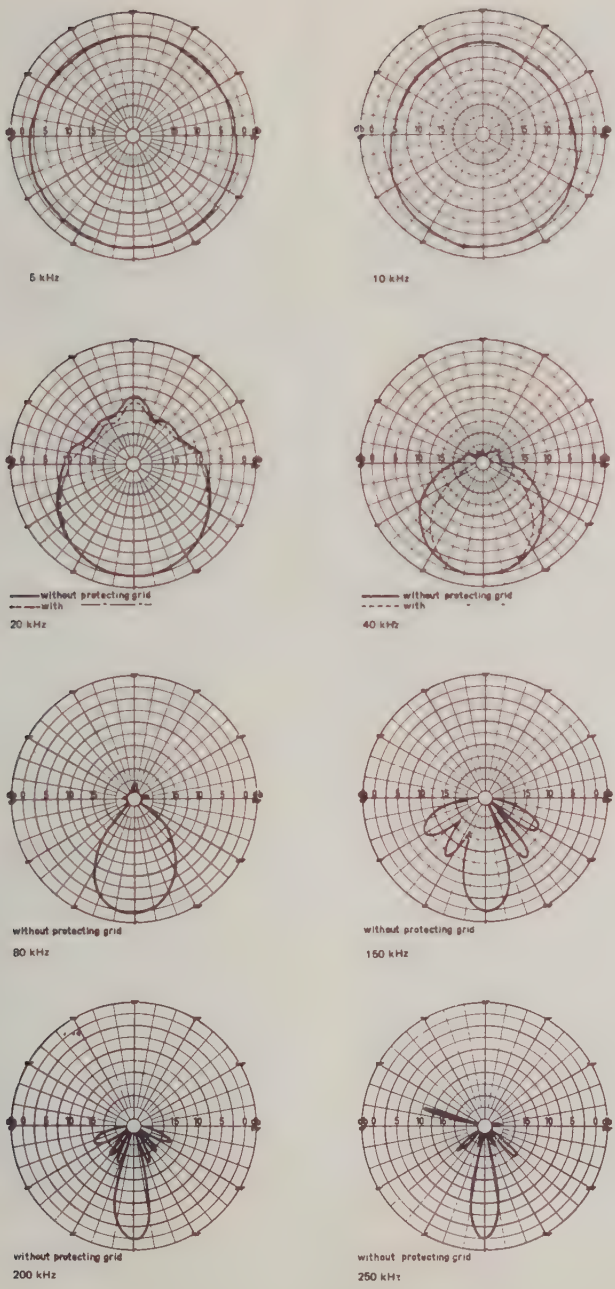

Figure 3-15. Typical directional patterns for the 1/2-in. condenser microphones. (Art, courtesy of Brüel & Kjaer.)

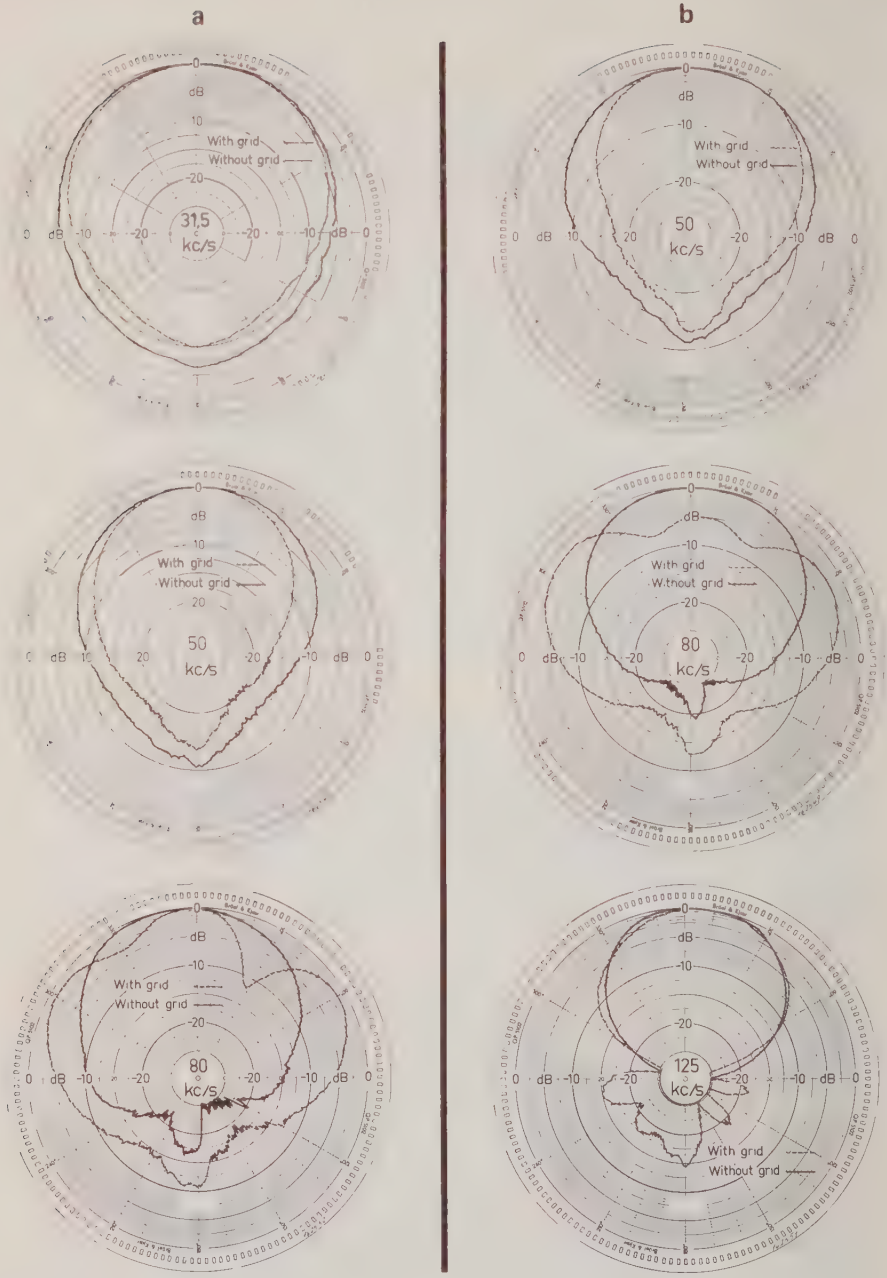

Figure 3-16. Typical directional patterns for the 1/4-in. condenser microphones supplied with a, Microphone Set 1560-9534, and b, Microphone Set 1560-9535. (Art, courtesy of Brüel & Kjaer.)

Figure 3-17. Typical directional patterns for the 1/8-in. condenser microphones without the protecting grid. (Art, courtesy of Brüel & Kjaer.)

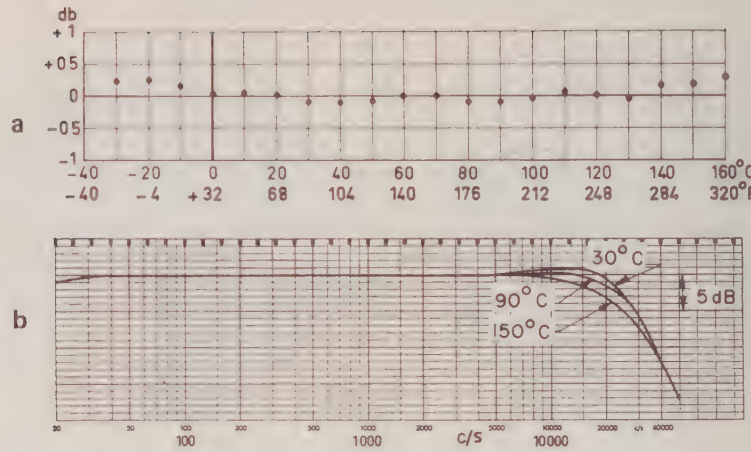

Figure 3-18. Influence of temperature on the sensitivity of the 1/2-in. condenser microphones; a, sensitivity at 400 Hz; b, typical frequency response vs temperature. (Art, courtesy of Brüel & Kjaer.)

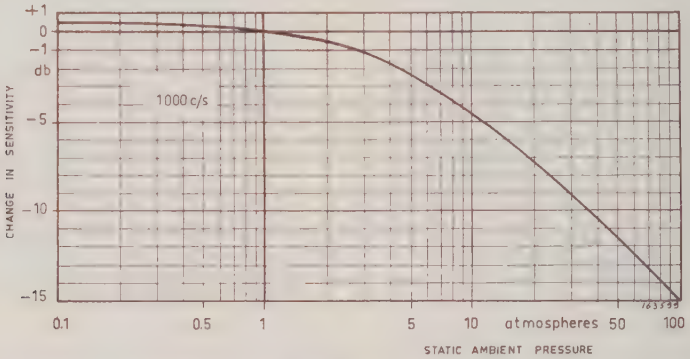

Figure 3-19. Variation in the sensitivity of the 1/2-in. condenser microphones as a function of the ambient pressure. (Art, courtesy of Brüel & Kjaer.)

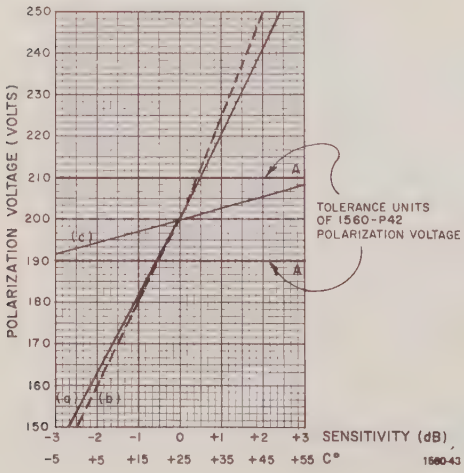

Figure 3-20. a) Variation in the sensitivity of the condenser microphones with changes in the polarizing voltage; b) proportional value neglecting the change in the air gap; c) change in polarizing voltage with temperature of the 1560-P42. Lines A-A show the tolerances of the polarizing voltage for the 1560-P42.

Type 1560-P42 Preamplifier-Section 4

4.1 DESCRIPTION 4-1
4.2 INSTALLATION 4-1
4.3 INPUT CONSIDERATIONS 4-8
4.4 USE OF LONG CABLES 4-9
4.5 NOISE 4-14
4.6 CIRCUIT DESCRIPTION 4-18
4.7 SERVICE AND MAINTENANCE 4-20

4.1 DESCRIPTION.

A complete description of the Type 1560-P42 Preamplifier (Figure 4-1) is given in para. 1.1.3.

Figure 4-1.
Type 1560-P42 Preamplifier with microphone attached.

4.2 INSTALLATION.

4.2.1 Connecting the Transducer.

NOTE

Although it is not necessary, it is good practice to turn off the power to the 1560-P42 Preamplifier while the transducer is being connected or disconnected. (The FET is diode protected against surges.)

Connection of the transducer to the Preamplifier is made by means of a 0.460-60 threaded coaxial connector. This connector provides electrical contact between the microphone shell and the Preamplifier circuit ground. The ground connection is electrically isolated from the case of the Preamplifier, which serves as a shield.

NOTE

The circuit ground of any adaptors that are used with the Preamplifier must be insulated from the shell of the Preamplifier, to preserve the 3-wire output consideration. All GR adaptors retain this feature.

The connection between circuit ground and shield is made at the analyzing instrument for all equipment. This connection must be provided to realize the full shielding capability of the -P42 Preamplifier (refer to the schematic diagram for output-connector pin destinations, Figure 4-18).

The input terminals of the Preamplifier provide a direct connection for all 1/2-in. GR microphones. To convert transducers of other sizes to this thread, the appropriate adaptor must be inserted between the transducer and the Preamplifier. The adaptors supplied with the sets and other available adaptors are described in para. 1.3 and shown in Figure 1-4.

The Preamplifier is adapted to 1-in. condenser microphones by use of the 1560-9542 adaptor. The B & K 1 in. condenser microphones mate directly with this adaptor. Because the depth of the center-pin contact of 1-in. microphone has not been standardized, standard 1-in. microphones, such as the WE 640AA and the MR 103, supplied with a small sliding center contact. This contact should be adjusted to the depth necessary to provide the required contact between the center pin of the microphone and the Preamplifier.

The GR Vibration Pickups, Types 1560-P52, -P53, and P54, can be connected to the Preamplifier by use of the 1560-9669 Adaptor. Other vibration pickups will require special adaptors for this connection.

4.2.2 Tripod Mounting.

The 1560-9580 Tripod is designed to accept the 1560-P42 Preamplifier. Complete instructions for its use are given in para. 1.3.5.

4.2.3 Output Connections.

The 10-ft output cable attached to the Preamplifier is terminated in a Switchcraft type 3A, 3-pin male connector that mates directly with similar female connectors on the 1560-P62 Power Supply and on most GR analyzers and sound-measuring instruments. The shield is connected to the outer shell of the Preamplifier, but is ***not*** connected to ground except at the analyzing instrument or by the output cable of the 1560-P62 Power Supply.

The pin connections for the Preamplifier output cable are as follows:

Pin 1 — circuit ground
Pin 2 — power-supply connection (+15 to 25 Vdc)
Pin 3 — output signal (from Preamplifier)
Shell — shield

NOTE

The circuit ground and the shell (shield) of the Preamplifier must be connected at the analyzer.

4.2.4 Adjustments.

Adjustment of the Preamplifier consists of setting two slide-switch controls labelled GAIN (X1, X10) and 200 V (ON, OFF). These are accessible through cutouts in the outer shell of the -P42. A notch in the slider of each switch is used to set the controls to one position or the other. Use any small tool (such as a screwdriver or ball-point pen) to set these controls.

Gain Adjustment. The gain of the Preamplifier can be set to either X1 or X10 by means of the GAIN switch. It should be set to optimize the dynamic range of the system. For low levels (such as less than 60 dB SPL for −60 dB microphone sensitivity level) and/or for long cable runs, set the GAIN switch to X10, to eliminate the influence of the analyzer noise on the measurement. With high signal levels (above 120 dB SPL for −60 dB microphone sensitivity level) set the GAIN switch to X1, so that the output signal will not be clipped because of overloading. For levels between 60 and 120 dB, either X1 or X10 can be used, the choice depending upon the reading desired on the indicating analyzer.

Polarizing Voltage. The +200-V polarizing voltage for condenser microphones can be turned ON and OFF by adjustment of the slide switch marked 200 V, on the Preamplifier. This voltage is generated in an internal blocking oscillator operating at approximately 60 kHz (refer to the schematic diagram). The voltage is applied to the center pin of the input connector through several decoupling networks. At least +15 V at the Preamplifier terminals is required to ensure stable generation of the 200 V. The 200-V supply is turned on by connecting the low-voltage supply to the oscillator through the 200 V (ON, OFF) switch. Set the switch ON for condenser microphones and OFF for ***all*** other transducers.

NOTE

The available current from the +200 V polarizing supply is extremely low and not hazardous. However, an increase in input noise due to leakage current may result if the polarizing voltage is left on with ceramic transducers. Use the +200 V supply only with condenser microphones.

The power consumption of the Preamplifier increases slightly when the polarizing supply is ON (the current increases about 2-3 mA above the current of the amplifier circuit of the Preamplifier).

4.2.5 Power.

The Preamplifier can be powered from a number of GR sound-level meters and analyzers, as shown in Table 1-2. The power is applied via the input connector to the Preamplifier. For use with instruments that do not supply power for the Preamplifier, or where insufficient current is available to power the polarizing supply, or for runs with long cables, the 1560-P62 Power Supply is available. This integrated charger and line/battery-operated supply provides the necessary current and voltage for most

applications. Refer to Table 1-2 and Figure 4-2 to determine the required current for the length of cable used. Details of the Power Supply and its use with the Microphone Sets are given in Section 5 of this manual.

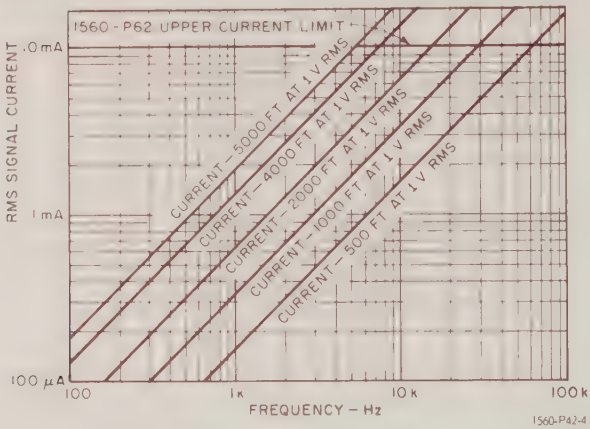

Figure 4-2. Required dc current vs cable length at 1 V, rms.

Although the 1560-P42 Preamplifier is designed to be used with GR instruments that supply the proper power, there may be instances in which the user wishes to use a different supply. This use is entirely satisfactory if certain precautions are taken:

With the class AB output stage, the power supplied to the Preamplifier must be current limited so that the output stage of the Preamplifier will not be damaged if the output is heavily loaded (such as with a short circuit) when a signal is applied to the load. Output currents above 30 mA at rated voltages should be avoided. GR analyzers and the 1560-P62 Power Supply provide this current limitation. Other supplies should be set to give a maximum short-circuit current of 15 mA. If this is not possible, insert a 100-Ω resistor in series with the supply lead (pin 2 of the -P42 output connector), to provide minimum protection (see Figure 4-18).

If the supply current is monitored with a dc milliameter, the true average current (other than the quiescent current) drawn by the 1560-P42 Preamplifier, when the load is driven by a sine wave, is actually twice the indicated current, because the current drawn from the positive lead of the power supply by the class AB output stage occurs during only the positive half of the cycle. In other words, therefore, the reading of an average-reading meter must not exceed 10 mA.

Average current to load $\simeq (mA_{reading} - mA_{quiescent}) \times 2$.

Note that, in a system where cables in excess of 1000 ft are driven, the placement of the power supply will influence the capability of the system (the IR drop in the cable becomes significant). Placement of the supply near the preamplifier will avoid the loss of the powering voltage through the long cable.

4.2.6 Insert Voltage.[1]

General. Provision for connecting an insert calibration signal is provided by a type-274 double jack (PL2) built into the output plug. The insert voltage can be used

1. For a complete discussion of the theory of insert-voltage calibration, refer to Beranek, L. L., *Acoustic Measurements*, John Wiley & Sons, Inc., New York, 1949, pp 601, 602.

to determine the system sensitivity if the open circuit sensitivity of the microphone is known, it can be used to determine the absolute calibration of the system by direct comparison with a reference microphone, also, an operational check on a system can be made with the insert voltage. The equipment needed for these operations is listed in Table 4-1. The insert terminating resistor is 10 Ω (R20) and the maximum insert voltage is 1 V rms. The signal is applied across the insert resistor, effectively putting the insert voltage in series with the transducer.

Table 4-1

EQUIPMENT REQUIRED FOR USE IN MEASURING SENSITIVITY

Name	Requirements	Recommended*
Oscillator	1 kHz, 1 V	GR Type 1310 Oscillator
Decade Attenuator	0-100 dB in 0.1-dB steps	GR Type 1450-TB Decade Attenuator
Voltmeter	0-10 V ac ±5%	GR Type 1808 AC Milli-voltmeter
Analyzer	C or FLAT weighting, 70-100 dB	GR Type 1564 Sound and Vibration Analyzer
Power Supply	20 V, 15 mA	GR Type 1560-P62 Power Supply
Resistor	590 Ω ±1%	———
Sound Source	Stable repeatable source	GR Type 1562 Calibrator
Reference microphone with adaptor to fit input to -P42 Preamplifier	Long-term stability; calibration traceable to NBS	W.E. 640AA
Patch Cords (2)	GR 274 to GR 274, 3 ft	GR Type 274-NQ
Adaptor	Microphone cartridge to 0.460x60 thread	GR 1560-9581
Clip Leads (2)	>1 foot long	———

*Or equivalent.

Determination of System Sensitivity. The following procedure should be used to determine the sensitivity of the system when the open-circuit sensitivity of the microphone is known:

a. Make the setup of Figure 4-3. Connect the oscillator to the 274 insert terminals (the connector at the end of the Preamplifier output cable). Connect the voltmeter between the threaded portion of the input connector and the shell of the Preamplifier, i.e. across the insert resistor (clip leads can be used). Power for the Preamplifier is not needed. In the figure, R_1 is the insert resistor (nominally 10 Ω) and R_W is the internal wiring resistance (typically a few tenths of an ohm).

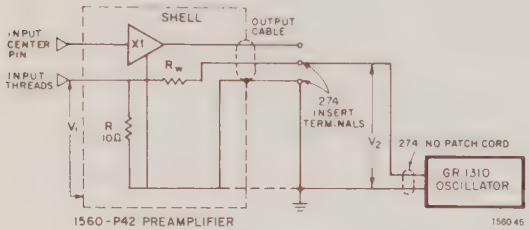

Figure 4-3. Setup for determination of system sensitivity.

b. Adjust the oscillator to 1 kHz. Set its output so that the voltmeter reads V_1 = .01 V.

c. Transfer the voltmeter to the insert terminals and read V_2. The indicated increase in voltage ($V_2 - V_1$) is caused by R_W and amplifier deviation from 0 dB, typically a total of −0.3 to −0.5 dB. This is the loss that must be added to the voltage at the insert terminals to give desired voltage across the insert resistor. Record this value for future use.

d. Remove the adaptor and install the microphone on the Preamplifier. Connect the plug on the output cable from the Preamplifier to the input of the 1564 Sound and Vibration Analyzer. Power for the Preamplifier is supplied by the 1564. The oscillator should remain connected to the insert-voltage terminals, with its output still set to the value of V_2, at 1 kHz.

e. With the Preamplifier operating on X1 gain, note the reading (V_3) of the analyzer (calibrated to read voltage). The difference in voltage ($V_1 - V_3$) is a result of the capacitive loading of the transducer by the Preamplifier and Preamplifier gain or loss.

The ratio of $\frac{V_1}{V_3}$ expressed in dB ($20 \log_{10} \frac{V_1}{V_3}$), is the value to be subtracted from the open-circuit sensitivity level of the microphone to obtain the system sensitivity level.

For example, if the sensitivity level of the microphone is −40 dB re 1 V/N/m^2 and V_1/V_3 = 1.175 (=1.4 dB), then the system sensitivity level is

$R_S = -40 - 1.4 = -41.4$ dB re 1 V/N/m^2.

If a more-accurate method is required, short the input with a GR 1560-9581 adaptor (with shorted terminals) and supply power to the −P42. Note the difference

between the voltage at the insert terminals and at the output of the P42 cable. This method removes simultaneously the errors due to amplifier gain and the wiring loss.

Comparison with Reference Microphone to Obtain Open-circuit Sensitivity.

a. Make the setup shown in Figure 4-4. The 590 Ω resistor at the attenuator output provides the proper 600 Ω load for the attenuator when the 10 Ω insert resistor is driven. Power for the Preamplifier is furnished by the 1564.

b. Connect the reference microphone to the P42, and place the 1562 Calibrator, set at 1 kHz, on the microphone. (The actual level of the calibrator signal is not important, but it must be repeatable.) Set the oscillator output at zero.

c. Read the voltage output from the Preamplifier on the analyzer. Record the value as V_{ref}. Remove the sound source.

d. Set the oscillator output level for maximum (approximately 10 V) at 1 kHz. Adjust the 1450-TB Attenuator to give a reading equal to V_{ref} on the 1564. Note the setting, A_1, of the attenuator.

e. Turn the oscillator output to zero. Replace the reference microphone with the unknown and place the sound source (1562) on the unknown microphone. Note the 1-kHz reading, V_{unk}, of the analyzer.

f. Remove the sound source and connect the oscillator as before, with the output setting used in step d (10 V). Adjust the 1450-TB attenuator to give a level equal to V_{unk} on the analyzer. Note the attenuator setting, A_2.

g. The open-circuit sensitivity level of the unknown microphone is then

$$S_{unk} = S_{ref} + (A_1 - A_2).$$

For example, if

$S_{ref} = -30$ dB re 1 V/N/m^2

$A_1 = 4.5$ dB

$A_2 = 13.5$ dB

then

$$S_{unk} = -30 + (4.5 - 13.5)$$
$$= -30 - 9.5$$
$$= -39.5 \text{ dB re } 1 \text{ V/N/m}^2$$

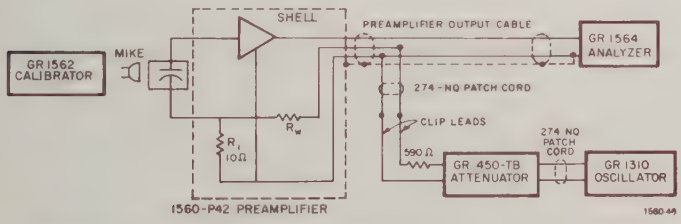

Figure 4-4. Setup for comparison of unknown with reference microphone.

Operational Check of System. When a system has been set up and calibrated, a voltage can be applied to the insert terminals to serve as a reference. Note the values of the insert voltage and the analyzer reading, for future reference. (The absolute values are not important.) As an operational check at a later date, or after system

modifications, the same voltage is applied to the insert terminals. A deviation in the analyzer reading from the original reading is an indication of a change in the system response.

4.3 INPUT CONSIDERATIONS.

The equivalent INPUT circuit of the Preamplifier is determined by the FET input stage and its associated biasing and protection networks. Protection for the transistor from surges of the polarizing voltage (with condenser microphones) is supplied by very low-leakage semiconductor diodes. These diodes produce a slight increase in the input capacitance and add some leakage resistance. The 200-V polarizing voltage is supplied through a "bootstrapped" 100-MΩ resistor, which, in effect, increases its ac resistance to well above 1 GΩ. The net input resistance is approximately 700 MΩ. The input capacitance is established by the FET plus the diodes, and is typically 3-4 pF, with 6 pF maximum. (Use of the driven shield minimizes the input capacitance for small diameter microphones.) As a result of this nominal input capacitance, there is some transducer insertion loss due to the resultant capacitive-divider effect. Figure 4-5 gives the insertion loss for microphones of various capacitances.

A low-frequency roll-off is encountered when the Preamplifier is driven from a capacitive source because of the equivalent input resistance. The "Lower" and "Upper Frequency Range" columns of Table 1-1 give the frequencies at which the response is down 3 dB, for the various microphones. Input protection diodes CR1 and CR2 utilize the signal-source impedance to limit the pk-pk input voltage to the power-supply value. If the 1560-P42 is driven from a 10-Ω or lower source impedance, such as that of a power amplifier, it is important to limit the pk-pk input voltage to the power-supply value, to avoid damaging CR1 or CR2.

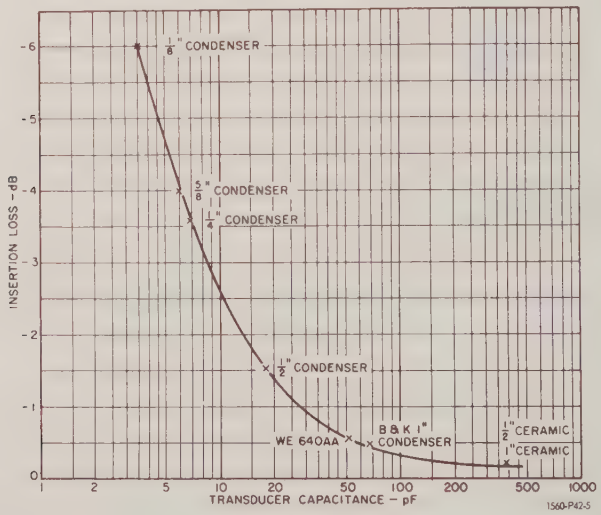

Figure 4-5. Insertion loss vs transducer capacitance.

4.4 USE OF LONG CABLES.

4.4.1 General.

The 1560-P42 Preamplifier is designed with the capability of delivering substantial signal current and signal voltage to the driven cable at the preamplifier output. Thus, longer cables can handle substantially higher signals at higher frequencies than were possible heretofore with other preamplifiers. However, to utilize this capability, the user must have a thorough understanding of the problems to be encountered.

In any system involving active amplification driving a load, the following effects, with their related causes, should be considered:

1. ***Distortion.*** Insufficient current to drive the particular load at the desired signal voltage level (i.e., the signal level is too high for the load).

2. ***Change in frequency Response.*** The output characteristics of the amplifier, in conjunction with the impedance of the load, alter the frequency response of the signal.

3. ***Attenuation.*** Also brought about by the interaction of the output amplifier impedance and the load impedance, this is a modification of 2, above, but it is generally considered a flat loss of signal with respect to frequency.

4. ***Power-supply voltage drop.*** This item is a fourth effect, resulting indirectly from the use of an amplifier powered through a long cable. The voltage drop in the power lead of the cable is a function of the resistance of the cable and the current drawn by the driving amplifier. If the amplifier is operating class A-B or B, the current is a function of the output level, the frequency, and the impedance of the cable being driven.

These general problems can be circumvented if one has a thorough knowledge of their causes. It is assumed, in the appraisal of the system, that the ultimate goal is the flattest possible frequency response, with minimum attenuation and minimum distortion, over the range of interest. The following paragraphs should bring about a better understanding of the problems and their solutions.

4.4.2 Definitions.

Short Cables. A short cable is one in which no appreciable change in performance of the system or in measurement results is produced in the frequency range of interest by use of the cable. Thus, for our analysis, short cables can be excluded. In general, short cables for use with the 1560-P42 Preamplifier are those that are 500 ft or less in length.

Long Cables. Long cables are those that alter the signal appreciably when driven by the preamplifier. For our analysis, long cables are those whose driving wavelength is much longer than the cutoff wavelength of the cable. If the frequency of the driving signal is above the cutoff frequency, the attenuation in the cable decreases uniformly as the square root of the frequency. However, for audio frequencies, the cable is invariably being driven well below cutoff frequency. Typically, the wavelength is greater than 5000 ft at 150 kHz for polyethylene dielectric cables.

4.4.3 Equivalent Circuits.

The sources of signal alteration in an amplifier/cable system can be demonstrated best by means of the equivalent circuit of the cable (see Figure 4-6) driven by the amplifier and the equivalent circuit of the output stage of the amplifier. It is the interaction of these elements that produces the alteration on degradation of the signal.

In most microphone/preamplifier applications, where low-level signals are involved, the cable is usually assumed to be an unterminated, unmatched line. It appears as a simple lumped capacitance at the output of the driving amplifier. The equivalent shunt capacitance at the output of the amplifier increases as the length of the cable increases. Thus, in conjunction with the output resistance of the amplifier, a 6-dB/octave low-pass filter is produced with the cutoff frequency decreasing as the length of the cable increases.

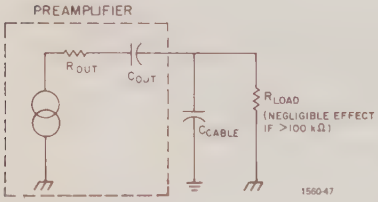

Figure 4-6. Equivalent circuits for the output stage of the Preamplifier and the cable.

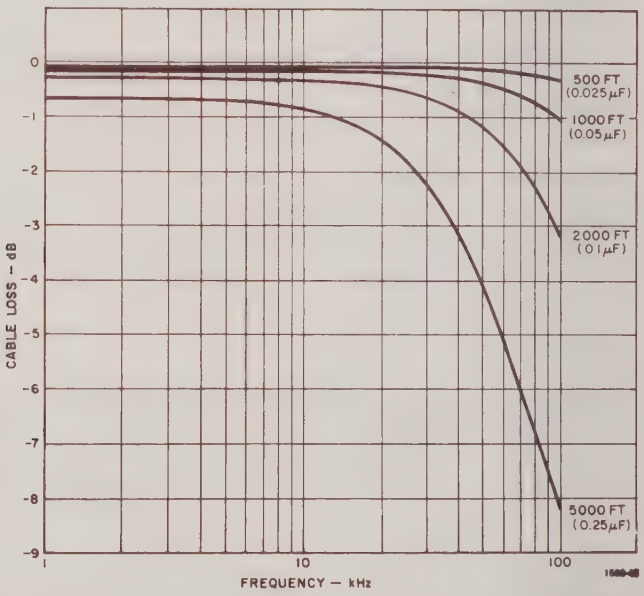

Figure 4-7. Typical cable loss vs frequency, due to output loading of 1560-P42 for a pure capacitance load. Cable capacitance is 50 pF/ft.

Certain cables, whose resistive and inductive reactances are *small* with respect to their capacitive reactance, do behave according to the above simple assumption. In reality, with most audio cables whose equivalent effective impedance is approximately 50 Ω, the resistive and inductive reactances are not negligible, and must, therefore, be taken into account. Indeed, as the cable length increases, the effective load impedance

for the amplifier never decreases to zero, but is restricted to the 50 Ω self termination of the cable. Also, a flat loss is introduced at low frequencies by the capacitive divider effect between the output coupling capacitor of the amplifier and the lumped cable capacitance. The cable loss vs frequency for various lengths of 1560 type 7 cable (Belden #8771)* is shown in Figure 4-7. For this curve, the capacitance only (50 pF/ft) is used as the effective impedance.

4.4.4 Cable Response.

Figure 4-8 shows the results of these effects on the response, using the same cables with a 1560-P42 Preamplifier. Because the cable is driven from a low impedance rather than its natural impedance (as would be the case in a matched line) the cable appears as a distributed tank circuit driven from a short circuit. The result is a family of curves with resonant peaks. The frequency is determined by the L/C constants of the cable, and the amplitude is determined by the ratio of the cable resistance to the amplifier output resistance. It should be noted that the actual equivalent circuit of the cable as used is not an unbalanced coaxial system, but rather a balanced system, because the cable braid is a shield, not a return path. This is important when the system response is

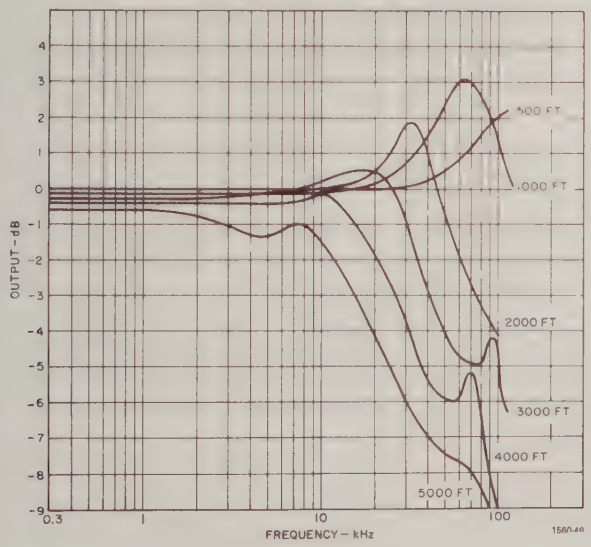

Figure 4-8. Measured cable loss of the Preamplifier vs cable length for Belden #8771 cable. Preamplifier gain is X 1, powered from the receiver end.

*Belden Corp., P.O. Box 5070-A, Chicago, Ill.

measured. The equivalent circuit of the cable is shown in Figure 4-9. For cables up to 5000 ft and frequencies up to 10 kHz, there is little effect on the signal. For longer cables or higher frequencies, the effect must be corrected, or it must be taken into account when the results are evaluated. This can be done by using corrective equalizers or by altering the results mathematically to give a flat frequency response. In both cases, a knowledge of the cable characteristics is needed.

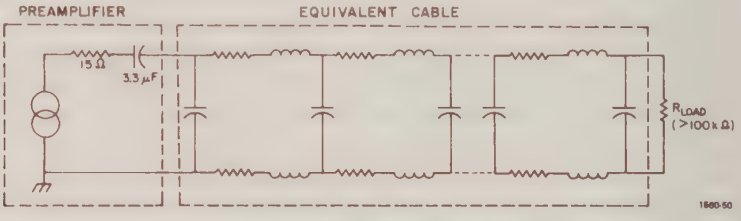

Figure 4-9. Equivalent circuit for long cables.

When a long connecting cable is used between the preamplifier and the measuring instrument, the output from the preamplifier may have to be restricted because of the low reactance load of the cable. Figure 4-10 shows the maximum rms sine-wave voltage at the output of the 1560-P42 versus frequency. The 1560-P62 current-limited Power Supply was used, and the distortion was limited to 1%. The curves are for Belden #8771 cable (50 pF/ft). Refer to Figure 4-11 to convert voltage to SPL in dB re 1 $V/N/m^2$ for a particular microphone. Divide by 10 to obtain maximum output volts with X10 gain on the Preamplifier.

4.4.5 Predicting the Resulting Response.

In general, the impedance of audio cables cannot be controlled, because of the twist of the inner conductors. The impedance may vary from 40 to 100 Ω, depending upon the make and the basic capacitance. While the resistance and capacitance of a cable can be measured quite easily, determination of the distributed inductance is more difficult. Also, once these parameters are known, it is tedious to calculate the response at all the required frequencies of interest. Even when this has been accomplished, it is well to check the results by making an actual measurement, rather than by attempting to predict the results.

4.4.6 Measuring the Cable.

To measure the cable, a stable oscillator and a wide-band voltmeter that cover the frequencies of interest are required. As noted above, the actual cable is a balanced system (i.e., the direct and return paths for the signal have practically the same resistance and inductance). Consequently, when the cable is measured, the return path of the cable must not be short-circuited by the common returns of the oscillator/analyzer combination. With this short circuit, measurements on a coiled cable in the laboratory will not be representative of the cable stretched out, in the field.

4.4.7 Using the Results.

The above measurements should be used to correct the results of the final analysis. A mathematical correction can be time consuming and too slow for real time analysis. Corrective equalizers can be constructed and placed at the analyzer end to return the signal to a flat frequency response.

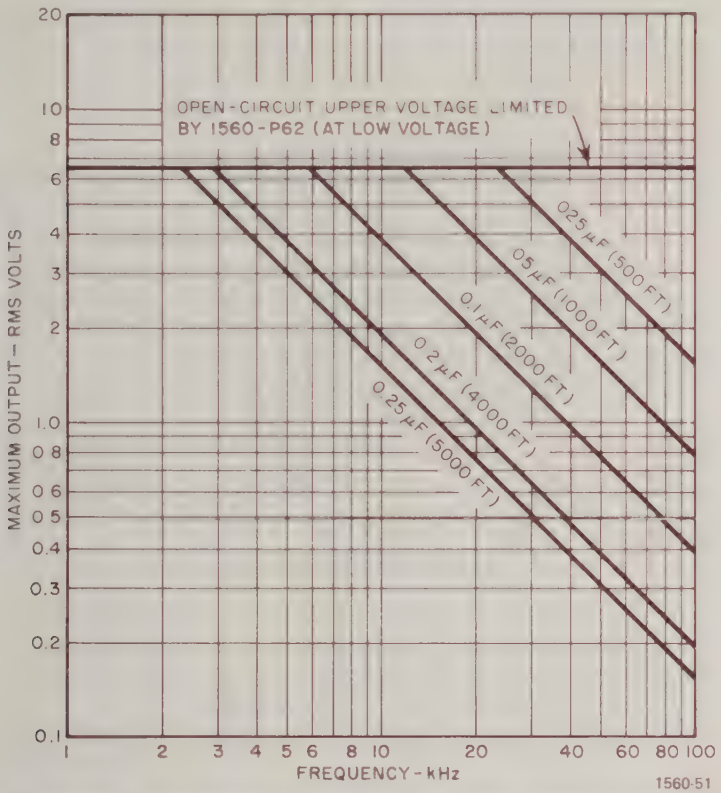

Figure 4-10. Maximum rms sine-wave output voltage for various lengths of Belden #8771 cable (50 pF/ft) at the output of the 1560-P42, using the 1560-P62 current-limited Power Supply with 1% total harmonic distortion limit.

4.4.8 Other Solutions.

Several methods are available to avoid the problem of frequency-response shift by long cables. However, they usually produce new problems:

1. Matching the Cable. This method requires matching the cable impedance at both the source and the load. There is then an automatic 6-dB loss in level, and additional power is required by the amplifier. Most audio cables are 50 Ω impedance; this means that 20 mA is required to drive 1 V rms into the cable. Also, a large output coupling capacitor is needed to drive the cable at low frequencies.

2. Using 600-Ω Cable. This is similar to the above solution. However, the higher impedance reduces the power requirement and the size of the coupling capacitor for

the matched system With this impedance level, interference is increased. Consequently, matching transformers are used to convert the line from low-impedance unbalanced-to-ground to 600-Ω balanced-to-ground. High-quality transformers must be used to affect a good solution.

3 Using Line Drivers With this method, amplifiers are placed in the line at such intervals that the frequency alteration is above the point of interest. This requires special feed-through amplifiers and greater power-supply capability.

4.5 NOISE.

4.5.1 Input Noise.

The major source of noise in the Preamplifier is the FET input stage[1] (refer to para. 4 6) However, some additional noise is produced by the protection diodes, CR1 and CR2. The noise spectrum is also influenced by the magnitude of the source capacitance This capacitance, in conjunction with the real input resistance, shapes the input noise spectrum Bootstrapped resistor R1 behaves like a resistor many times larger with respect to the input signal, but for noise, it appears as 100 MΩ.

Figure 4-12 shows the basic 1/3-octave noise spectra from 25 Hz to 25 kHz for several typical source capacitances. The vertical coordinates are given in equivalent sound-pressure noise levels for a microphone sensitivity level of −40 dB re 1 V/N/m^2. Refer to Figure 4-11 to convert the levels to those for microphones of other sensitivities. For example, if the equivalent noise level with a −40 dB re 1 V/N/m^2 microphone is 10 dB, a −50 dB re 1 V/N/m^2 microphone would give an equivalent noise level of 20 dB.

Table 4-2 gives A- and C-weighted and flat-response noise levels for the various source capacitances.

Table 4-2.

INPUT-CIRCUIT NOISE FOR THE 1560-P42 PREAMPLIFIER

Source Impedance	Noise (dB)* A weighting	C weighting	Flat
600 Ω	20.5	22.5	24.5
390 pF	20.5	23.0	25.0
68 pF	23.5	30.0	34.5
47 pF	24.5	32.0	36.0
18 pF	29.0	38.0	41.5
6.8 pF	34.0	43.0	46.0
4.7 pF	36.0	45.0	47.0

*Equivalent sound level for a microphone with a sensitivity level of −40 dB re 1 V/N/m^2 uncorrected for capacitance loading.

1. Johnson, J. B., *Thermal Agitation of Electricity in Conductors*, Physical Review, Vol 32, July 1928. pp 97-109.

Van Der Ziel, A., *Thermal Noise in Field Effect Transistors*, Proc IRE 50, 1962 pp 1808-1812.

Sanderson and Fulks, *A Simplified Noise Theory and Its Application to the Design of Low Noise Amplifiers*, GR Reprint A-88.

NOTE

Although it is not necessary, it is good practice to disconnect the preamplifier power before removing or attaching the microphone.

A period of 10-20 s is required for the input capacitor to discharge through the internal circuitry after the capacitor has been charged to 200 V.

In addition to providing protection for the FET, diodes CR1 and CR2 limit the peak-to-peak input signal to the power supply voltage. Also, the recovery time for large overloads is greatly enhanced by these diodes, i.e., the amplifier will stabilize in a very short time after overloads.

The effect of the protection diodes, CR1 and CR2, and resistor R1 is to increase the C-weighted noise for 390-pF sources by 1.5 to 2.5 dB and for 18 pF sources by 5 to 7 dB.

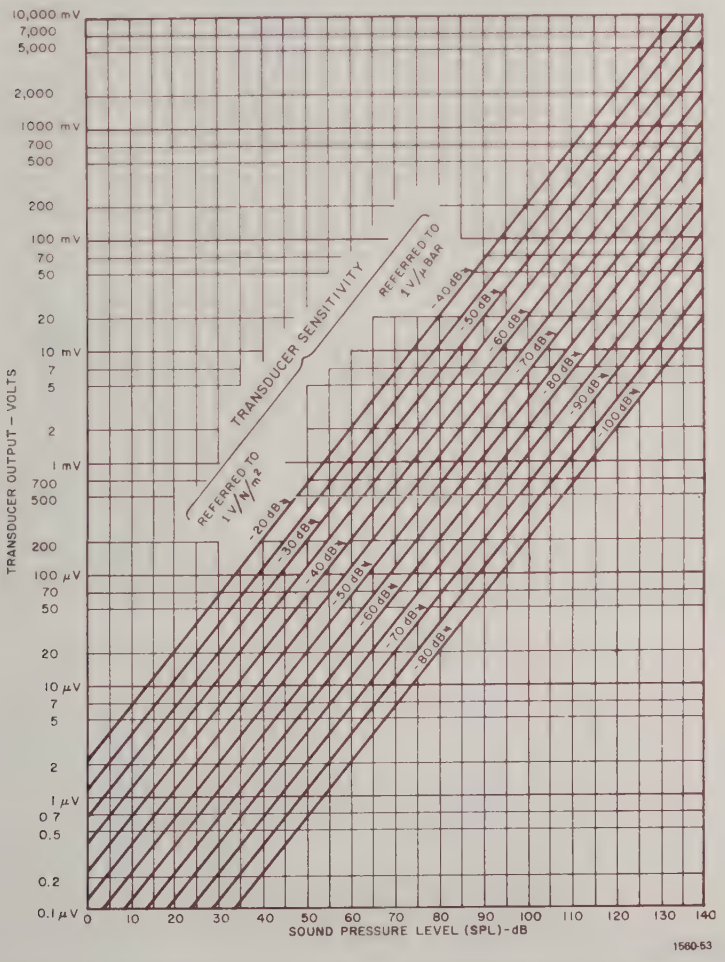

Figure 4-11. Open-circuit output voltage vs SPL for microphones of various sensitivities.

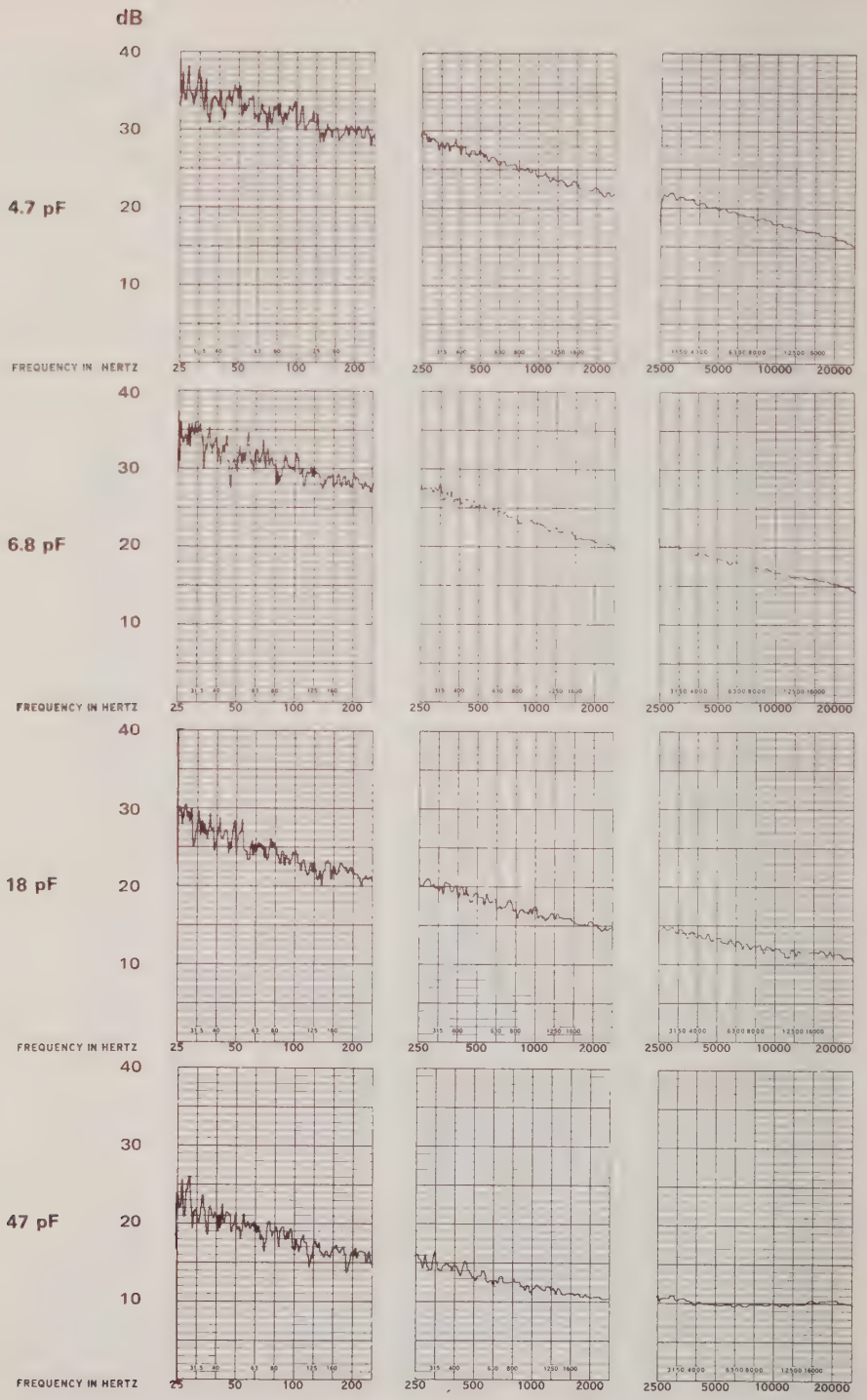

Figure 4-12. Basic 1/3-octave noise spectra for microphones of various source impedances.

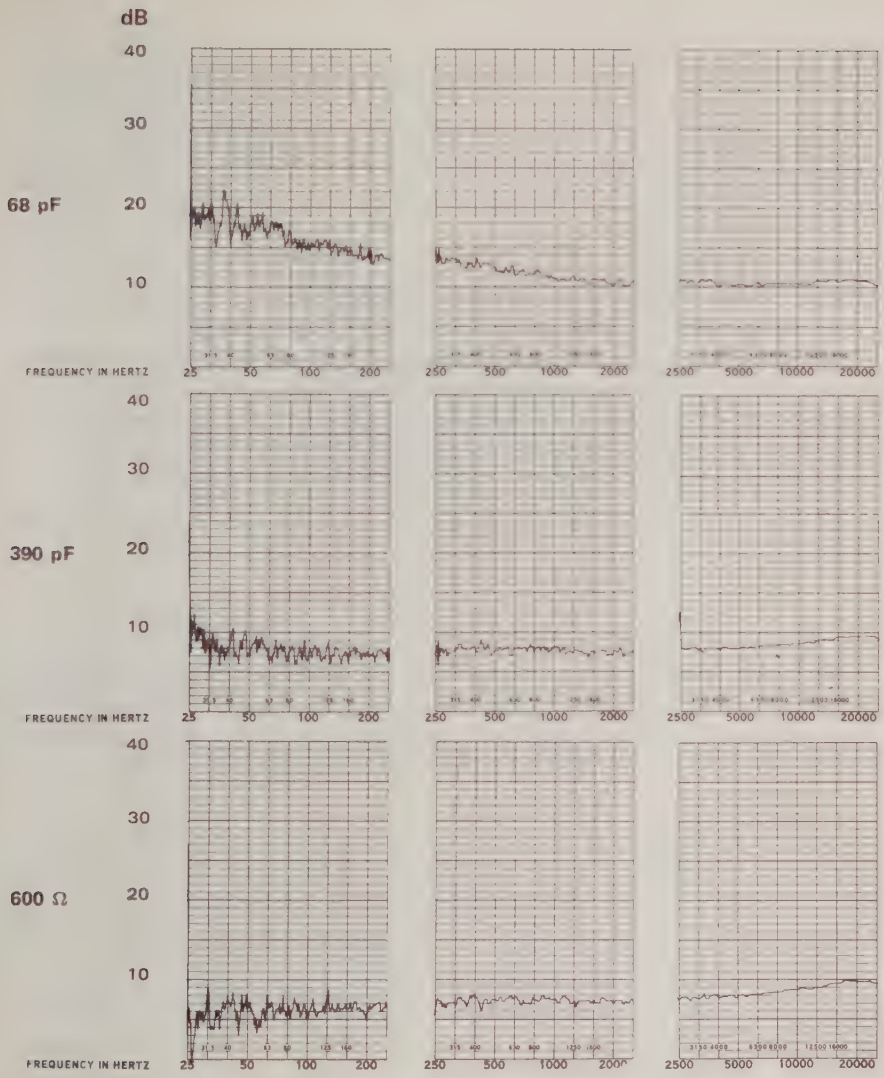

FIGURE 4-12 (cont)

4 5.2 Oscillator Noise.

The source of the polarizing-voltage for condenser microphones is a dc-to-dc converter consisting of a blocking oscillator and doubler-rectifier-filter circuit. The oscillator frequency is typically 60 kHz. Residual oscillator noise is filtered out by the weighting networks or by the filters in the subsequent analyzer.

An analysis using a 1/4-in. or 1/8-in. microphone may require measurements within the frequency range of the oscillator operation. The user should be aware of the

magnitude of the oscillator spurs in any analysis. Equivalent input-signal peaks of approximately 6 μV on X1 gain or 18 μV on X10 gain at the fundamental oscillator frequency are typical. Upper harmonic spurs are 3-4 dB lower in magnitude. The size of the spur is relatively independent of the microphone capacitance. Refer to Figure 4-11 to relate this undesired signal level to the equivalent input sound-pressure level for the particular microphone being used.

4.5.3 Low-Supply-Voltage Noise (Oscillator Motorboating).

If the power-supply voltage drops below + 15 V dc, the 200-V polarizing supply will not regulate properly. The result is a low-frequency noise produced by changes in the polarizing voltage. To verify this cause, switch off the 200-V polarizing voltage (the switch on the 1560-P42). If, after the amplifier stabilizes, the noise disappears, a low power-supply voltage should be suspected. Note that condenser-microphone operation requires 2-3 mA more supply current than operation with ceramic microphones. With long cables, the power-supply voltage will drop as a result of quiescent and signal currents. Refer to Table 1-2 to determine whether or not the power supply is operating out of its range.

4.5.4 Power-Supply-Noise Rejection.

If the 1560-P42 Preamplifier is driven from a noisy power source (such as a dc-dc converter regulator), it is often useful to know the degree with which power-supply noise will interfere with the signal. A measure of power-supply noise attenuation vs frequency for a typical microphone/preamplifier combination is given in Table 4-3.

Table 4-3.

Attenuation of power-supply noise*

Frequency (Hz)	Rejection (dB)	
	X1 Gain	X10 Gain
2	−29	−11
10	−40	−20
100	−46	−25
1,000	−46	−25
10,000	−46	−25
100,000	−44	−17

***Measured at the output of the 1560-P42 Preamplifier. Source capacitance of microphone is 390 pF.**

4.6 CIRCUIT DESCRIPTION.

4.6.1 Amplifier Section.

The 1560-P42 Preamplifier consists of two main sections: an amplifier, to provide the gain, and an oscillator, to furnish the polarizing voltage for condenser microphones. To provide the high impedance required for use with either ceramic or

condenser microphones, the 3-stage amplifier section incorporates a low noise FET (Q1) in the input (refer to the schematic diagram, Figure 4-18).

The incoming signal is ac coupled to the gate of Q1. The gate potential is established by the voltage divider, R2 and R3. Approximately half of the dc power-supply voltage is introduced at the gate of Q1. For maximum gain and minimum noise, Q1 should operate near its IDSS value (the value of the current through the drain when the source is shorted to the gate). Resistors R5 and R8 are factory selected, to establish a bias for Q1 such that it will operate near its IDSS value.

Protection against input surges is provided by diodes CR1 and CR2.

A complete dc feedback loop gives increased stability. The 2 position GAIN switch (SW1) is located in the feedback path.

The class AB output stage (Q3, Q4) provides up to 10 mA peak and greater than 1 V rms, to feed long lengths of cable. Crossover distortion is reduced by slight bias via double diode CR3 and resistors R12 and R13. The loading of voltage amplifier Q2 is kept to a minimum by use of high-gain transistors, Q3 and Q4.

A slight roll-off at high frequencies is produced by C3 and R9, to eliminate oscillations at unity gain.

Because of the capacitive nature of the microphones, loading of the capacitive element should be minimized. This is accomplished by placing a driven shield around the input lead. The shield is driven from the source of Q1. Thus, effectively, no potential difference exists between the shield and the input lead, and, during measurements, loading is kept to a minimum.

The output impedance of the Preamplifier is very low (15 Ω in series with 3.3 μF). Normally, it should feed a 100 kΩ (or higher) impedance such as that of a sound-level meter or analyzer. Resistor R15 is inserted in series with the load and provides additional phase margin for capacitive loads. It also prevents damage to the Preamplifier if the output is inadvertently shorted. To give additional short-circuit protection ***the current from any power supply used with the Preamplifier must be limited to 15-20 mA***, as is the case with most GR analyzers and the 1560-P62 Power Supply.

4.6.2 Oscillator Section.

The oscillator section of the Preamplifier supplies the 200 V required by condenser microphones for polarization. This voltage is derived from the pulse transformer T1 and transistor Q5. The oscillator operates at approximately 60 kHz, well above the usual audio spectrum.

Capacitor C6 is charged through resistor R16, turning on transistor Q5. The feedback winding of oscillator transformer, T1, turns off Q5. The turn-on pulse is

transformed by T1 to > +100 V output pulse. Diodes CR5, 6, and 7 serve as a voltage doubler and CR8 is a low-noise rectifier with a breakdown of 200 V.

4.7 SERVICE AND MAINTENANCE.

4.7.1 GR Field Service.

The 1560-P42 Preamplifier is covered by the two-year warranty given at the front of this manual.

The two-year warranty attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial, ID, and type numbers of the instrument.

4.7.2 Instrument Return.

Before returning an instrument to General Radio for service, please contact our Service Department or nearest District Office requesting a "Returned Material" number. Use of this number will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

4.7.3 Minimum – Performance Standards.

The equipment listed in Table 4-4 is required for incoming inspection, periodic operational checks, or trouble analysis of the Preamplifier. The procedures are given in the following paragraphs.

The special dummy microphone used for the noise test consists of a Switchcraft 390P1 adaptor with a 390-pF capacitor inserted between terminals 1 and 3, on one end.

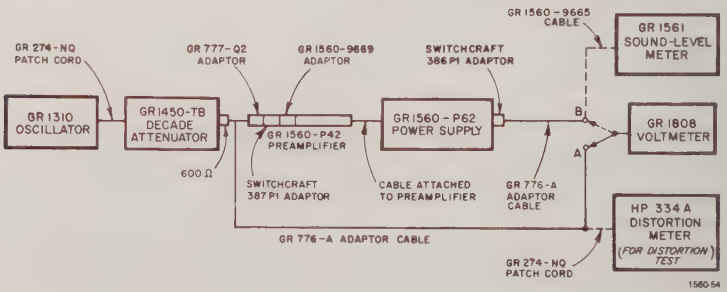

Figure 4-13. Test setup for minimum-performance checks.

Table 4-4

TEST EQUIPMENT

Name	Minimum Requirements	Recommended*
Oscillator	3 Hz-500 kHz 100 mV – 1 V open circuit	GR Type 1310
Decade Attenuator	0-40 dB in 10-dB steps	GR Type 1450-TB
Sound-Level meter	40-150 dB C Weighting	GR Type 1561
Distortion Analyzer	To measure <0.25% distortion	Hewlett Packard Distortion Meter, Model 334A
Ac Voltmeter	100 mV - 1 V	GR Type 1808
Voltmeter	0.2 - 2 V 3 – 20 Hz	Ballantine 316
Power Supply	20 V dc, 15 mA	GR Type 1560-P62
Resistor	600 Ω ±1% (termination)	
Patch cord (2 needed)	GR274 to GR274, 3 ft	GR Type 274-NQ
Adaptor cable (2 needed)	GR274 to BNC plug (male)	GR Type 776-A
Shielded cable	3-pin microphone connector (male) to 3-pin microphone connector (female)	GR Type 1560-9665
Adaptor	GR274 to phone jack	GR 777-Q2
Adaptor	Phone plug to 3-pin female microphone connector	Switchcraft 387P1
Adaptor	3-pin microphone connector	GR 1560-9669
Adaptor	3-pin female microphone connector to BNC plug	Switchcraft 386P1
Special Dummy Microphone	(refer to text)	
Voltmeter	0-25 V, 20,000 Ω/V, accuracy ±2%	GR Type 1806
Oscilloscope	Bandwidth – 50 MHz Rise Time – 1 ns	Tektronix Model 547 with 1A1 plug-in unit

*or equivalent

Gain Check (X1). Make the setup shown in Figure 4-13. The 1808 Voltmeter is to be connected alternately at the output of the 1450-TB Decade Attenuator (connection A in the diagram) and the output of the 1560-P62 Power Supply (connection B).

Use the following procedure:

Set

1450-TB	Attenuation – 0 dB
1310-B	FREQUENCY – 1 kHz
	OUTPUT – 1 V rms
1560-P42	200 V switch – OFF
	GAIN switch – X1
1560-P62	Switch – LINE ON
1808	METER RANGE – 1.5 V

a. Adjust the 1310 output for a reading of +8 dB on the meter at the output of the 1450 attenuator (connection A).

b. Change to connection B. The 1808 must now read 8 ±0.3 dB.

Gain Check (X10). Change the above settings of Figure 4-13 as follows.

1450-TB	Attenuation – 20 dB
1560-P42	GAIN switch – X10

The 1808 must now read 8 ± 0.3 dB.

Frequency Check. Using either the 1808 Voltmeter or the Ballantine 316 Voltmeter in the setup of Figure 4-13, make the frequency measurements indicated in Table 4-5. In each case, perform step A with the voltmeter at point A, then step B, voltmeter at point B.

Table 4-5
FREQUENCY CHECKS

1310 Frequency	1560-P42 Gain	Voltmeter Used	1450-TB Attenuation (dB)	Step A: Reference On Voltmeter Range	Step A: Reference On Voltmeter dB Setting	Step B: 1560-P42 Output (dB)
3 Hz	X1	316	20	2 V	10	7 to 13
5 Hz	X1		20	2 V	10	9 to 11
20 Hz	X1		20	2 V	10	9.75 to 10.25
3 Hz	X10		40	0.2 V	10	7 to 13
5 Hz	X10		40	0.2 V	10	8.5 to 11.5
20 Hz	X10		40	0.2 V	10	9.7 to 10.3
100 Hz	X1	1808	20	1.5 V	8	7.75 to 8.25
10 kHz	X1		20	1.5 V	8	7.75 to 8.25
100 kHz	X1		20	1.5 V	8	7.75 to 8.25
500 kHz	X1		20	1.5 V	8	7 to 9
100 Hz	X10		40	0.15 V	8	7.7 to 8.3
10 kHz	X10		40	0.15 V	8	7.7 to 8.3
100 kHz	X10		40	0.15 V	8	7.7 to 8.3
300 kHz	X10		40	0.15 V	8	6 to 10

Noise Check. In the setup of Figure 4-13, connect the 1808 Voltmeter to point A and the 1561 Sound-Level Meter to point B (the output from the 1560-P62 Power Supply); use the GR 1560-9665 cable. The procedure is given below

a. Set:

1450-TB	Attenuation – 20 dB
1310-B	FREQUENCY – 1 kHz
	OUTPUT – 100 mV (read on 1808)
1808	METER RANGE – 150 mV
1560-P42	GAIN – X10
	200 V – OFF
1560-P62	Switch – BAT ON (no power cord connected)
1561	Attenuation – 130 dB
	WEIGHTING – C
	METER – SLOW

b. Adjust the CAL control on the 1561 so that its meter reads 134 dB

c. Remove the input to the 1560-P42 at the output of the 387-P1 adaptor. With the 1560-9669 adaptor still in place, insert the dummy microphone at the input

d. Change the 1561 attenuation to 40 dB.

The 1561 must now read less than 45 dB.

Distortion Check. Make the setup of Figure 4-13. Connect the 334A Distortion Meter to point B.

a. Set:

1450-TB	Attenuation – 0 dB
1310-B	FREQUENCY – 1 kHz
	OUTPUT – 1 V rms
1560-P42	GAIN – X1
	200 V – OFF
1560-P62	Switch – LINE ON
334A	FUNCTION – DISTORTION

b. Measure the distortion on the 334A to be less than 0.25%.

c. Change the output from the 1310-B to 0.1 V rms (at the input to the 1560-P42) and set the GAIN switch on the 1560-P42 at X10. Again the distortion must be less than 0.25%. If the distortion is higher, check the oscillator distortion (at point B).

4.7.4 Trouble Analysis.

The following details should be helpful in locating the faulty component, if trouble develops in the Preamplifier. When components are disconnected or replaced, use good soldering technique. Use a small tip on the iron and fine-gauge solder. Keep the heat to a minimum.

Amplifier Section. Terminate the input in 600 Ω and turn the 200 V switch off. Table 4-6 gives the transistor voltages with a power-supply voltage of 20 V. Use the GR 1806 Voltmeter (or equivalent) for the measurements. Connect the negative terminal to the ground of the power supply (not to the Preamplifier shield). Be sure pin #1 is connected to ground.

Also, check the + terminal of capacitor C4. With the GAIN switch on X10, this should be approximately 10 V (1/2 of the power-supply voltage). If C4 is at B+, Q2 is

probably shorted, and should be replaced (see base connections on the schematic diagram). A short circuit between the drain and source of Q1 will cause Q2 to conduct too heavily, in which case, replace Q1. If it is replaced, resistors R5 and R8 must be selected according to the IDSS value of Q1, the value of the current through the drain when the source is shorted to the gate. Determine the IDSS value by using the circuit of Figure 4-14. Then select Allen Bradley 1/8-W, 5% resistors as shown by Table 4-7.

CAUTION

When changing Q1, use a small soldering-iron tip and fine-gauge solder, with only enough heat to produce good connections. Overheating diode CR1 or CR2 may produce noise, requiring its replacement.

Table 4-6

TRANSISTOR VOLTAGES

Location		Volts
Q1	gate	——
	source	11.5
	drain	+19.4 (-0.6)
Q2	emitter	20.0
	base	19.4
	collector	12.0
Q3	emitter	11.4
	base	12.0
	collector	20.0
Q4	emitter	11.4
	base	10.8
	collector	gnd

Table 4-7

SELECTION OF BIAS RESISTORS FOR Q1.

IDSS Value of Q1 (μA)	R5 (kΩ)	R8 (kΩ)
50-100	12	150
100-175	6.2	75
175-250	3.3	43

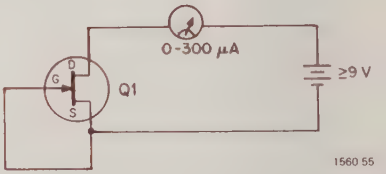

Figure 4-14. Circuit for the determination of the IDSS value of Q1.

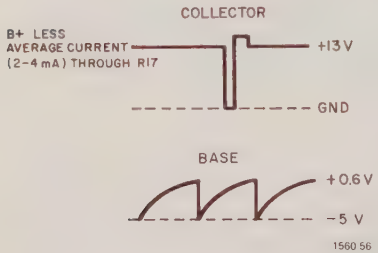

Figure 4-15. Waveforms at transistor Q5.

Oscillator Section. Check the waveforms at Q5, using the fast-rise-time pulse oscilloscope. The waveforms are shown in Figure 4-15.

A dc check for continuity can be made on the transformer windings.

To check for 100 V at the junction of CR5 and CR6, use the 1806 Voltmeter on OPEN GRID. There should be 200 V at the anode of CR7. Diodes CR5, 6, and 7 are very fast rise- and recovery-time diodes, rated at 225 V. Replacements should be made only with type 1N661 diodes, from Texas Instruments Incorporated (Dallas, Texas).

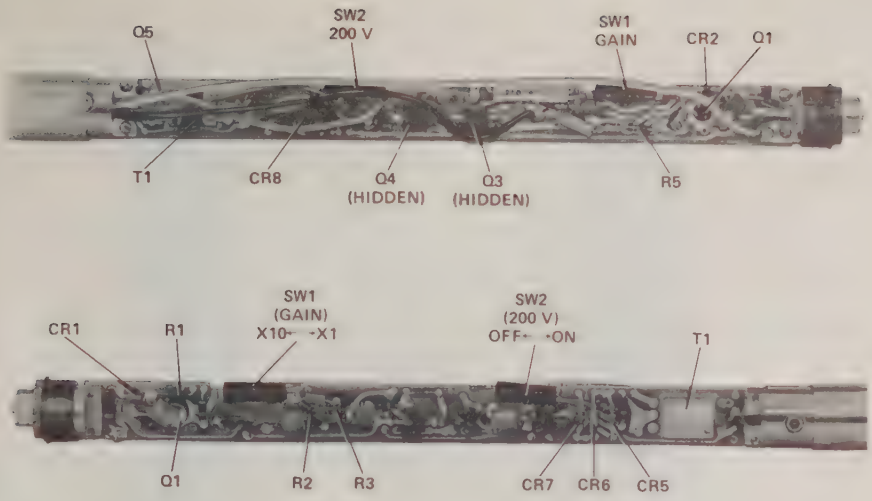

Figure 4-16. Interior views of the 1560-P42 Preamplifier; (top) circuit side of etched-circuit board; (bottom) component side.

1560-P42 PREAMPLIFIER

ELECTRICAL PARTS LIST

Ref Des	Description	GR Part No.	Fed Mfg Code	Mfg Part No.	Fed Stock No.
CAPACITORS					
C1	Ceramic, .001 µF, 10%, 200 V	4400-6440	72982	8121-026-X5RO-102K	
C2	Electrolytic, 80 µF, 20%, 15 V	4450-6300	37942	MTP, 80 µF, 20%	
C3	Ceramic, .001 µF, 10%, 200 V	4400-6440	72982	8121-026-X5RO-102K	
C4	Electrolytic, 3.3 µF, 20%, 60 V	4450-6310	37942	MTP, 3.3 µF, 20%	
C5	Electrolytic, 10 µF, 20%, 30 V	4450-6320	37942	MTP, 10 µF, 20%	
C6	Ceramic, 330 pF, 10%, 200 V	4400-6441	72982	8111-026-X5RO-331K	
C7	Electrolytic, 1 µF, 20%, 35 V	4450-6400	56289	162-D, 1 µF, 20%	
C8	Ceramic, .001 µF, 10%, 200 V	4400-6440	72982	8121-026-X5RO-102K	
C9	Ceramic, .001 µF, 10%, 200 V	4400-6440	72982	8121-026-X5RO-102K	
C10	Ceramic, .001 µF, 10%, 200 V	4400-6440	72982	8121-026-X5RO-102K	
C11	Ceramic, .01 µF ±20% 200 V	4400-6444	72982	8121-M200-651-103M	
C12	Ceramic, .001 µF, 10%, 200 V	4400-6440	72982	8121-026-X5RO-102K	
CONNECTORS					
PL1	Multiple Plug	4220-3000	82389	83M	
PL2	Multiple Plug	4230-2500	82389	A3F	
DIODES					
CR1	Type DHD707	6082-1009	07910	DHD707	5961-929-9967
CR2	Type DHD707	6082-1009	07910	DHD707	5961-929-9967
CR3	MPD200	6082-1033	06751	MPD-200	
CR4	Type DHD707	6082-1009	07910	DHD707	5961-929-9967
CR5	Type 1N661/TI-UNI-G Package	6082-1032	06751	1N661	
CR6	Type 1N661/TI-UNI-G Package	6082-1032	06751	1N661	
CR7	Type 1N661/TI-UNI-G Package	6082-1032	06751	1N661	
CR8	Type CSR-1758D	6083-1079	07910	CSR1758D	
CR9	Type 1N750	6083-1003	07910	1N750	
RESISTORS					
R1	Comp., 100 MΩ, 10%, 1/8 W	6098-7109	01121	BB, 100 MΩ, 10%	
R2	Comp., 100 kΩ, 5%, 1/8 W	6098-4105	01121	BB, 100 kΩ, 5%	

Ref Des	Description	GR Part No.	Fed Mfg Code	Mfg Part No.
RESISTORS (Cont)				
R3	Comp., 120 kΩ, 5%, 1/8 W	6098-4125	01121	BB, 120 kΩ, 5%
R4	Comp., 1 GΩ, 20%, 1/8 W	6098-8108	01121	BB, 1 GΩ, 20%
*R5	Comp., 3.3 k-12 kΩ, 5%, 1/8 W	6098-2335, -2625 or -3125	01121	BB, 3.3 k-12 kΩ, 5%
R6	Comp., 3.0 kΩ, 5%, 1/8 W	6098-2305	01121	BB, 3.0 kΩ, 5%
R7	Film, 1.05 kΩ, 1%, 1//0 W	6619-3100	75042	CEA-TO, 1.05 kΩ, 1%
*R8	Comp., 43 k-150 kΩ, 5%, 1/8 W	6098-3435, -3755 or -4155	01121	BB, 43 k-150 kΩ, 5%
R9	Comp., 100 Ω, 5%, 1/8 W	6098-1105	01121	BB, 100 Ω, 5%
R10	Film, 10.6 kΩ, 1%, 1//0 W	6619-3101	75042	CEA-TO, 10.6 kΩ, 1%
R11	Comp., 10 kΩ, 5%, 1/8 W	6098-3105	01121	BB, 10 kΩ, 5%
R12	Comp., 27 Ω, 5%, 1/8 W	6098-0275	01121	BB, 27 Ω, 5%
R13	Comp., 27 Ω, 5%, 1/8 W	6098-0275	01121	BB, 27 Ω, 5%
R14	Comp., 100 kΩ, 5%, 1/8 W	6098-4105	01121	BB, 100 kΩ, 5%
R15	Comp., 10 Ω, 5%, 1/4 W	6099-0105	01121	BB, 10 Ω, 5%
R16	Comp., 100 kΩ, 5%, 1/8 W	6098-4105	01121	BB, 100 kΩ, 5%
R17	Comp., 220 Ω ±5%	6098-1225	01121	BB 220 Ω ±5%
R18	Comp., 10 MΩ, 5%, 1/8 W	6098-6109	01121	BB, 10 MΩ, 5%
R19	Comp., 100 MΩ, 10%, 1/8 W	6098-7109	01121	BB, 100 MΩ, 5%
R20	Comp., 10 Ω, 5%, 1/8 W	6098-0105	01121	BB, 10 Ω, 5%
R21	Comp., 3 kΩ, 5%, 1/8 W	6098-2305	01121	BB, 3 kΩ, 5%
R22	Comp., 100 MΩ, 10%, 1/8 W	6098-7109	01121	BB, 100 MΩ, 10%
SWITCHES				
SW1		(1560-7620) (1560-8700)	24655	1560-7620, 1560-8700
SW2		(1560-7620) (1560-8700)	24655	1560-7620, 1560-8700
TRANSFORMERS				
T1	Transformer Asm.	1560-4140	24655	1560-4140
TRANSISTORS				
Q1	Type 2N3457	8210-1082	17856	2N3457
Q2	Type D30A3	8210-1204	24454	D30A3
Q3	Type 2N4124	8210-1154	04713	2N4124
Q4	Type 2N3906	8210-1112	04713	2N3906
Q5	Type D26E1	8210-1205	24454	D2GE1

*Lab Adjust

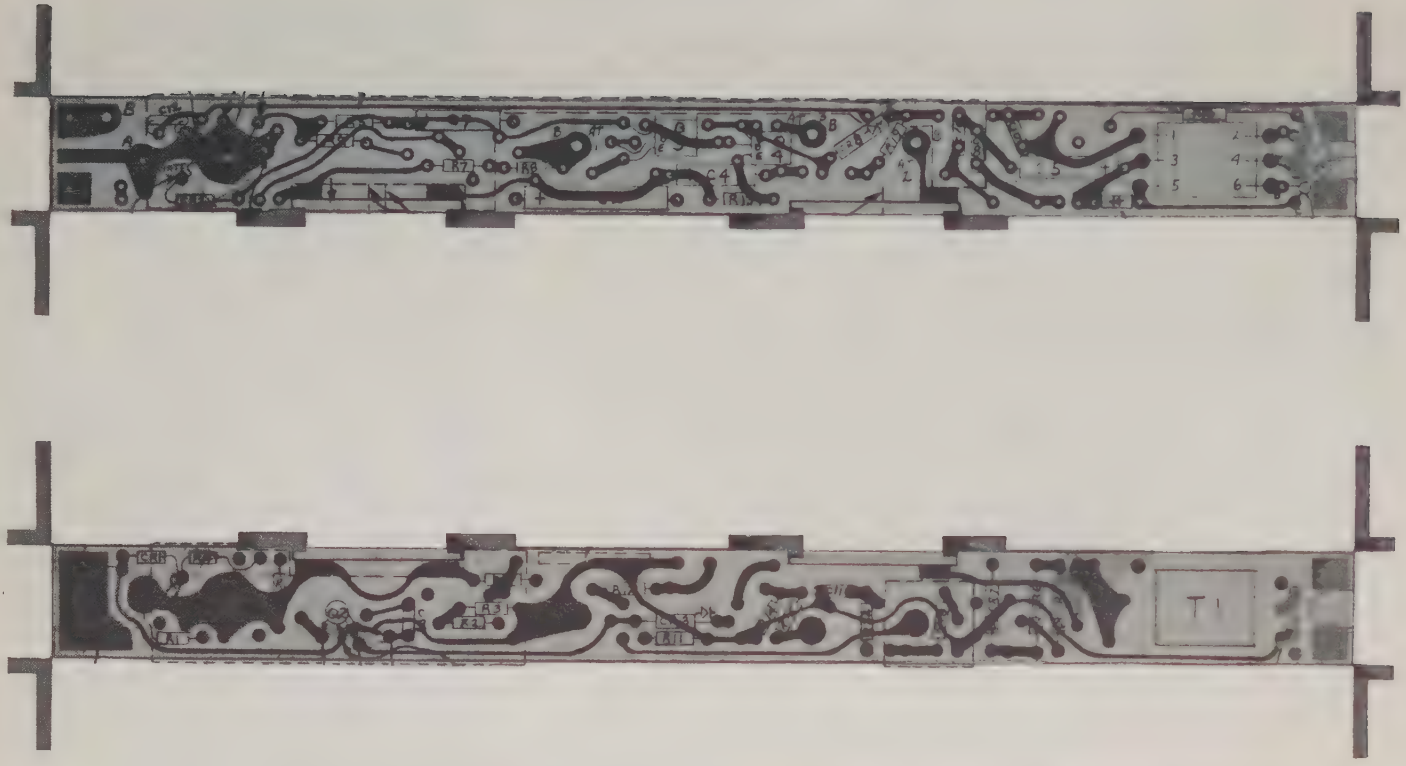

Figure 4-17. Etched-circuit board (P/N 1560-2791) for the 1560-P42 Preamplifier; (top) circuit side; (bottom) component side.

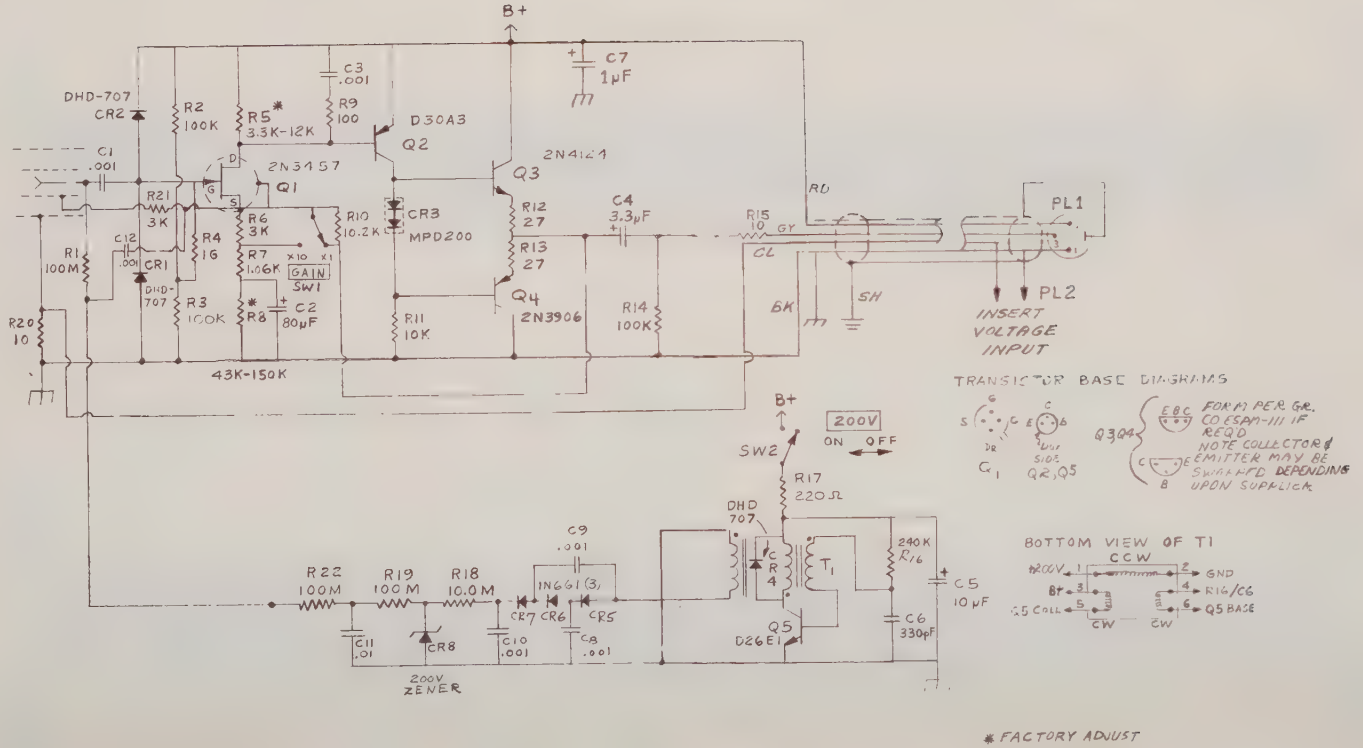

Figure 4-18. Schematic diagram for the 1560-P42 Preamplifier.

Type 1560-P62 Power Supply
Section 5

5.1 DESCRIPTION 5-1
5.2 CONTROLS, CONNECTORS, AND INDICATORS 5-2
5.3 ACCESSORIES SUPPLIED 5-3
5.4 INSTALLATION 5-4
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5.6 REMOTE OPERATION 5-6
5.7 BATTERY TEST 5-6
5.8 CHARGING THE BATTERY 5-7
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5.10 SERVICE AND MAINTENANCE 5-8

5.1 DESCRIPTION.

The 1560-P62 Power Supply (Figure 5-1) is intended to supply power to the 1560-P42 Preamplifier when the latter is used with instruments that do not include the necessary source of power (refer to Table 1-2). The Power Supply can also be used when long cables are to be driven at high levels. It can serve as a charger for rechargeable batteries in other instruments, such as the 1561 Sound-Level Meter and the 1952 Universal Filter.

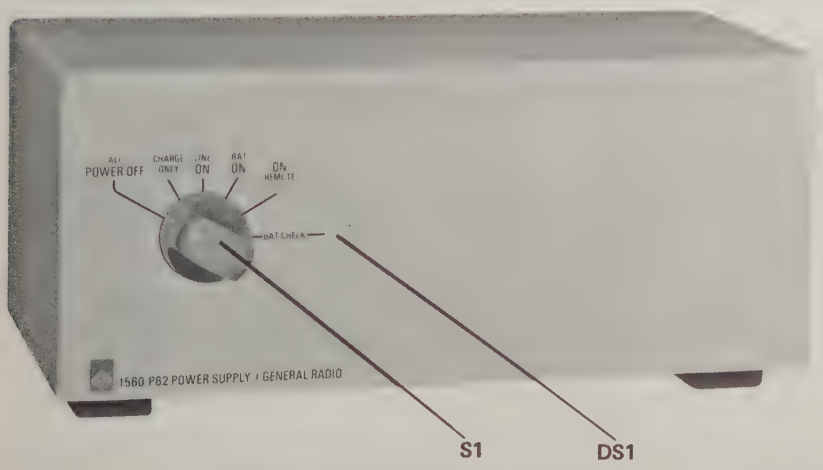


Figure 5-1. Type 1560-P62 Power Supply.

Included in the Power Supply are two nickel cadmium rechargeable batteries, a battery-charging circuit, and a battery-checking circuit. The batteries are held in a slide-out clip, for easy removal.

Specifications for the 1560-P62 Power Supply are given at the front of this manual

5.2 CONTROLS, CONNECTORS, AND INDICATORS.

5.2.1 Front-panel Controls and Indicators.

The front panel contains one selector switch (S1) and a battery-test light (DS1). The switch turns off the power to the unit in the ALL POWER OFF (ccw) position.

In the CHARGE ONLY position, with the line connected to the power line, the batteries accept current only from the line. In this mode, a full 22-mA charging current is applied to the batteries.

In the LINE ON position, the batteries are again charged with 22 mA, but battery voltage is also applied to the output connector from the preamplifier. (Some increase in ripple will be noted in this position.) The batteries act as a filter to the line, and any loading from the preamplifier reduces the charging current to the batteries (the current is limited to 22 mA).

In the BATtery ON mode, the line is disconnected from the unit; there is no line current in the transformer and the batteries are connected to the load.

With the switch in the ON, REMOTE position, the batteries are connected to the load when the instrument to which it is connected has at least 1 mA at 15 V on pin 2 of its input connector. In this mode, the on-off switch of the analyzing instrument becomes the on-off switch for the Power Supply.

The BAT CHECK position gives a spring-loaded momentary test of the battery. The front-panel pilot lamp (DS1) will light if the battery is charged sufficiently for operation. The light is used as a measure of the state of charge of the battery. It will not light if the battery voltage drops below 17 V. Since the change of illumination with voltage is rather sharp, the relative intensity of the light can be used as a measure of the state of charge of the batteries. For the test, the switch is held in the BAT CHECK position for several seconds. If the light intensity gradually diminishes somewhat during that time, the battery should be charged.

5.2.2 Rear-panel Controls.

The CHARGE switch (AS2) on the rear panel permits connection of the charging circuitry to either the INTernal BATtery (normal operation) or an EXTernal BATtery. In the EXTernal BATtery position, charging voltage is applied to the TO EXTERNAL BATTERY connector, AJ4 (see Figure 5-2). Connection from AJ4 to instruments such as the GR 1561 Sound-Level Meter is made by the cable (P/N 1560-0491) supplied with the -P62 Power Supply.

Slide switch AS1 (50-60 Hz, 100 V – 125 V, 200 V – 250 V) is used to select the proper line voltage, either 100-125 or 200-250 V.

Connection for the INPUT (FROM PREAMP) is made at connector AJ2, a 3-contact female Switchcraft type A3 connector, and connection for the OUTPUT

(TO ANALYZER) is made at AJ3, a 3-contact male type A3 connector. The signal passes directly from pin 3 of the INPUT to pin 3 of the OUTPUT. Note that the shield of the connectors is not connected to the circuit ground, but is connected to the case of the -P62 Power Supply. ***Ultimate connection of the ground to the connectors must be made at the final analyzing instrument.***

5.3 ACCESSORIES SUPPLIED.

The accessories supplied with the Power Supply are listed in Table 5-1

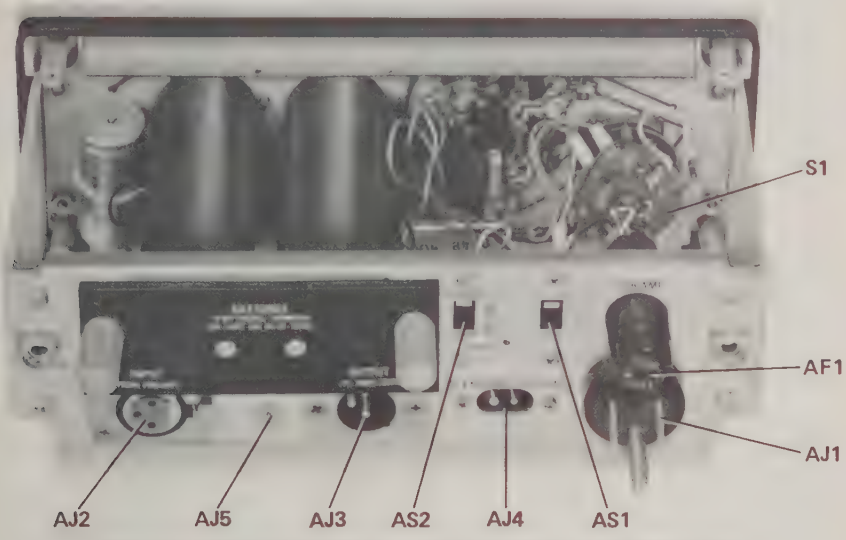


Figure 5-2. Controls and connectors on the rear panel of the Power Supply.

Table 5-1

ACCESSORIES SUPPLIED

Quantity Supplied	Item	Use	GR Part No.
1	Charging cable (20 in)	Connects TO EXTERNAL BATTERY socket to 1561 charging terminals.	1560-0491
1	Extension cable (4 ft)	Connects OUTPUT socket to an analyzer with female Switchcraft type A3 input connector.	1560-9665
1	Adaptor cable	Connects OUTPUT socket to an analyzer or recorder with type 274 double-plug input connector.	1560-2660

5.4 INSTALLATION.

5.4.1 Power.

The power cable (P/N 4200-9622, supplied) connects to AJ1, a polarized male plug. Line-power protection is afforded by a 1/16-A slow-blow fuse in an extraction-post fuse holder, AF1.

5.4.2 Dimensions.

The dimensions of the 1560-P62 are shown in Figure 5-3.

5.4.3 Mounting.

The 1560-P62 Power Supply may be ordered completely assembled in a metal cabinet, ready for bench use (P/N 1560-9575). The instrument is locked in the cabinet by two captive 10/32 screws in the rear panel.

The -P62 may also be ordered for mounting in an EIA standard 19-inch relay rack. This version (P/N 1560-9576) includes a rack-adaptor set (P/N 0480-9742), consisting of the parts listed in Table 5-2. The method of mounting is shown in Figure 5-4 and the procedure is as follows:

a. Loosen the two captive 10/32 screws in the rear of the cabinet until the instrument is free; slide the instrument forward, out of the cabinet.

b. Remove the four rubber feet from the cabinet. Be sure to save all parts as they are removed, for possible reconversion of the instrument to bench mounting.

c. Pierce and push out the plugs from the four bosses (C) in the sides of the cabinet, near the front. The blank panel can be attached to either side of the cabinet, as desired Use the holes in the side toward the blank panel. Do not damage the threads in the holes.

d. Press the subpanel (D) into the blank panel (E), to form a liner for the latter.

e. Place the blank panel so that the short flange of the subpanel is toward the cabinet. Attach the blank panel (E) and subpanel (D) to the cabinet, using two 5/16-in. screws (F) as shown. Note that the screws enter in opposite directions -- one from inside the cabinet and one from the flange side, as shown.

f. Attach one Rack Adaptor Assembly (handle) to the side of the cabinet opposite the blank panel, using two 5/16-inch screws (L). Again, note that the screws enter in opposite directions one from inside the cabinet and one from outside. Use the upper and lower holes in the Assembly.

g. Attach the other Rack Adaptor Assembly (handle) to the wide flange on liner (D) and the flange on the blank panel (E). Use two 5/16-in. screws (M) through the two holes in the flange that are nearest the panel and through the upper and lower holes in the Assembly. Again, the screws enter in opposite directions.

h. Install the instrument in the cabinet and lock it in place with the two captive screws through the rear panel that were loosened in step a.

i. Slide the entire assembly into the relay rack and lock it in place with the four 9/16-in. screws (N) with captive nylon cup washers. Use two screws on each side and tighten them by inserting a screwdriver through the holes (P) in the handles.

To reconvert the instrument for bench use, reverse the above procedures, first re-

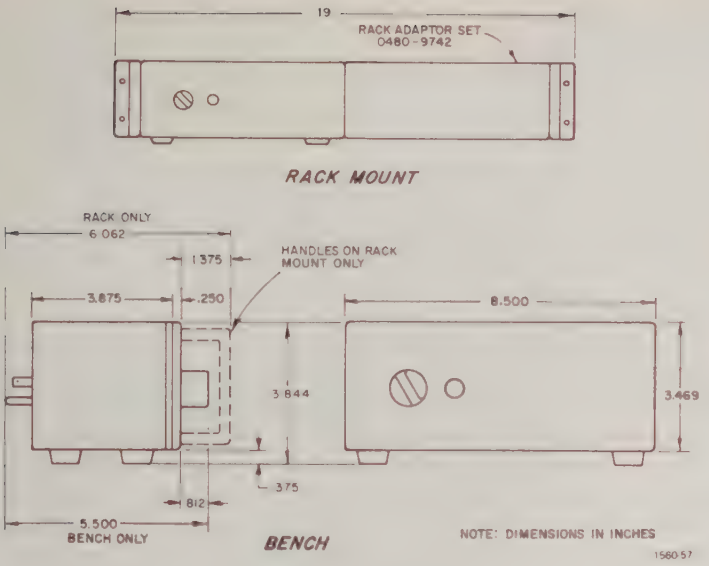


Figure 5-3. Dimensions of the Power Supply.

Table 5-2

PARTS INCLUDED IN THE RACK ADAPTOR SET
P/N 0480-9742 (see Figure 5-4)

Fig. 5-4 Ref.	No. Used		GR Part No.
E	1	Blank Panel	0480-8932
D	1	Sub-Panel	0480-8952
—	2	Rack Adaptor Assembly	0480-4902
H	1	Support Bracket	0480-8523
—	1	Hardware Set	0480-3080
		Includes	
F,J,K,L,M, N		8 Screws, BH 10-32, 5/16"	
		4 Screws, BH 10-32, 9/16" w. nylon cup washers	

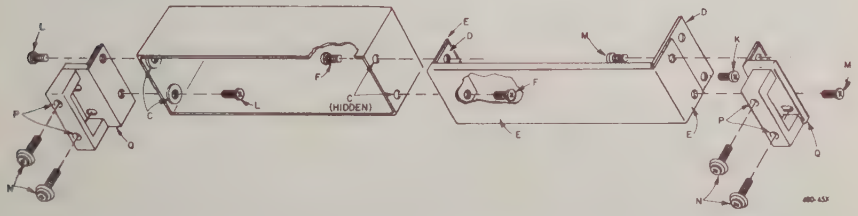


Figure 5-4. Method of mounting the Power Supply and a blank panel in a relay rack.

moving the entire assembly of instrument, cabinet, and blank panel from the rack. Next remove:

1. The instrument from its cabinet.
2. The blank panel (E) (with handle attached) from one side of the cabinet;
3. The Rack Adaptor Set (handle) from the other side of the cabinet.

Push the four rubber feet into the cabinet. Install the instrument in its cabinet and lock it in place with the two captive screws through the rear panel.

5.5 OPERATION.

Set the external charging switch to INTERNAL BATTERY and the front panel control to LINE ON. The instrument will now provide sufficient current and voltage to the INPUT (FROM PREAMP) connector to operate a 1560-P42, 1972-9600 (or 1560-P40) Preamplifier for upwards of 100 hours of continuous operation. The actual time will vary, depending upon the amount of signal current that the preamplifier presents to the load, and whether or not the -P42 is used for ceramic or condenser microphones. If the Power Supply is not plugged into the ac line, the LINE ON and BATTERY ON modes are identical. In the LINE ON position and if the Supply is plugged into the ac line, however, depending upon the state of charge of the batteries, some small ripple component may be seen as dc output that drives the Preamplifier. If there is a hum problem, setting the front-panel control to BATTERY ON will remove any connection to the ac line.

5.6 REMOTE OPERATION.

Set the front-panel switch to REMOTE. Connect the output of the -P62 Power Supply to any instrument that normally supplies at least 1 mA and at least 15 V at pin 2 of the connector to which the output of the -P62 is connected. Turning the analyzing instrument on and off will now turn the 1560-P62 on and off. No remote charging is provided by this remote connection.

5.7 BATTERY TEST.

Without connecting the power supply to 110-V (220-V) source, check that the batteries are inserted in the power supply and the battery switch on the rear panel is set to INTernal BATtery. Rotate front panel switch to BATtery CHECK position. The front panel lamp (DS1) should light. If not, the batteries need charging.

5.8 CHARGING THE BATTERY.

Before connecting the Power Supply to the line, be sure to set the power-voltage switch to the proper position. Connect the line voltage to the input-power connector. Set the front-panel switch to either CHARGE ONLY or LINE ON, depending on how

the instrument will be used. If the batteries have been fully discharged, they should be recharged for approximately 12 to 14 hours (overnight is usually satisfactory). If the -P62 is going to be used in the LINE ON position to recharge the batteries, some allowance must be made for the nominal load.

CAUTION

DO NOT overcharge the batteries by leaving the instrument in the charge mode for more than several days. Long-term (weeks) charges should be strictly avoided.

Charging an External Battery. To charge an external battery, connect the cable supplied (P/N 1560-0491) to battery terminal AJ4, EXTERNAL BATTERY. Connect the other end to the instrument whose batteries are being charged, such as the 1561. Set the 1561 to CHARGE. Set the rear-panel charge switch on the Power Supply to EXT BAT and the front-panel switch to CHARGE ONLY. The charging current will now be applied to the 1561 batteries. The 1561 batteries can be used in the OPERATE or LINE ON modes in the -P62.

5.9 THEORY.

The schematic diagram of the Power Supply is given at the end of this Section, in Figure 5-7.

The 1560-P62 Power Supply consists of two nickel-cadmium rechargeable batteries and related charging, testing, and overload-protection circuitry. The charging circuitry consists of power transformer T1, rectifiers CR1 through CR4, and either R1 or R2. These elements compose a constant-current charging circuit for the batteries. The current-limiting resistor is R1 or R2, which is connected to the line voltage (R1 or R2 depending on whether line switch S1 is connected to 110 or 220 V). This resistor, in conjunction with the winding resistance of the T1 primary winding, provides the constant-current charging for the batteries.

The open-circuit voltage at the secondary of T1 is approximately 60 V. However, when loaded with the batteries, a constant current of approximately 22 mA is fed into the batteries. In the event that the batteries are removed, diodes VR1 and VR2 behave as voltage-limiting devices so that, in the charge-operate mode, 25 V maximum will appear at the dc output terminals of the Power Supply. It should be noted that, because there is constant current in the batteries, the batteries should not be left in the charge mode constantly, as damage will probably result.

Transistor Q1, in conjunction with R3, R4 and VR3, behaves as a sensing device to denote whether or not the battery is adequately charged. It does this by loading the batteries with a modest discharge and sensing the voltage at the battery terminals. If the voltage is sufficiently high, pilot light DS1 will be illuminated.

The load current of the Power Supply is limited to 20-mA peak as a result of the current limiting action of Q1 and Q2 in conjunction with R39, CR5 and CR6. The

nominal maximum current limit is 15 mA. The true nominal is in the vicinity of 20 mA to allow for normal tolerances in semiconductor elements and temperature variations. Q2 is turned on via transistors Q3 and Q4. This circuitry provides the additional feature that a short-circuit continuously applied to the output of the Power Supply will not drain the batteries to the point where they will become dead. This is done by sensing the voltage at the battery terminals. If the voltage drops below 16 V, then the current supplied to Q2 to turn it on is removed. This is done via Zener diode VR4 and transistor Q3. This feature lengthens the life of the batteries many times over, because excessive discharge to zero will reverse-polarize the batteries and make them useless. The dc output of the Supply is applied to pin 2 of AJ2, which is the jack into which the preamplifier is connected. No voltage is applied to the output connector AJ3 of the Power Supply. However, AJ3 is used so that, for remote applications, where it is desirable to utilize a second instrument to turn on and off the Power Supply, pin 2 of AJ3 provides the sensing terminal. Such instruments as the 1564, 1921, 1558 and many other GR instruments, have nominal 1 or 2 mA at 16 V available at pin 2 of their connections. This small current and voltage is used to turn on Q4 of the -P62 Power Supply and affords a remote turn-on and turn-off feature. It must be noted, however, that in the remote mode the battery-low sensing circuitry is not operative.

5.10 SERVICE AND MAINTENANCE.

5.10.1 GR Field Service.

The 1560-P62 Power Supply is covered by the two-year warranty given at the front of this manual.

The two-year warranty attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see last page of manual), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial, ID, and type numbers of the instrument.

5.10.2 Instrument Return.

Before returning an instrument to General Radio for service, please contact our Service Department or nearest District Office requesting a "Returned Material" number. Use of this number will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

5.10.3 Trouble Analysis.

Table 5-3 shows the dc voltages at various points in the circuitry. The cabinet on the instrument is removed by unscrewing the two captive Phillips-head screws through the back panel.

Two general problems that might arise are no charging of the batteries, or no output voltage. The transformer and rectifier diodes are seldom at fault, but the

batteries may be dead. Either remove the batteries or set the battery switch to EXT BAT. With the line connected and the front-panel switch at CHARGE ONLY, +25 V should appear from wire tie 5 (WT5) to ground. If this voltage is incorrect, determine and replace the faulty component in the charging network. If the voltage is correct, re-install the batteries and again observe the voltage at WT5 in the CHARGE mode. If the voltage drops to zero, the batteries are probably shorted and should be replaced. If the voltage at the output of AJ3 (pin 2) is less than 18 V with good batteries, check that the turn-on circuitry is operating. Check the voltages on Q3 and Q4 according to Table 5-3. If they are correct, the trouble is probably a faulty Q2; if they are not, check Q3 or Q4 or Zener diode VR4. As a final check, short pin 2 of AJ3 to ground. The voltage across R9 should be approximately 0.6 V. This assures proper current limiting through Q2.

Table 5-3

DC VOLTAGES

	C	B	E
Q_1*	6.9	7.2	6.8
Q_2†	20.8	20.4	21.0
Q3	6.9	7.2	6.8
Q4	7.2	7.8	7.2

*Voltages with front panel switch in BAT CHECK position.

†Depends on battery voltage. Table based on fully charged battery of 21 V and no load.

1560-P62 POWER SUPPLY
MECHANICAL PARTS LIST

Fig Ref 5-5/5-6	Qnt	Description	GR Part No.	Fed Mfg Code	Mfg Part No.
FRONT PANEL					
1.	1	Cabinet, convertible bench:	4181-2911	24655	4181-2911
	1	Cabinet gasket	5331-3086	24655	5331-3086
	4	Foot	5260-2060	24655	5260-2060
2.	1	Knob asm. ALL POWER OFF/CHARGE ONLY/LINE ON/BAT ON/BAT ON REMOTE/BAT CHECK, including retainer 5220-5402	5500-5321	24655	5500-5321
REAR PANEL					
1.	2	Nuts for battery cover asm.	1521-6610	24655	1521-6610
2.	1	Battery cover asm.	1560-1350	24655	1560-1350
3.	2	Slide switch, A-S1, LINE VOLTAGE SELECTOR; A-S2, CHARGE	7910-0832	82389	11A-1118
4.	1	Fuse mounting device	5650-0100	71400	HKP-H
5.	1	Power plug, A-J1	4240-0600	24655	4240-0600
6.	1	Plug asm., A-J4, TO EXTERNAL BATTERY	1561-2040	24655	1561-2040
7.	1	Multiple plug, A-J3, OUTPUT (TO ANALYZER)	4220-3100	71468	XLR-3-32
8.	1	Multiple socket, A-J2, INPUT (FROM PREAMP)	4230-2600	82389	D3F

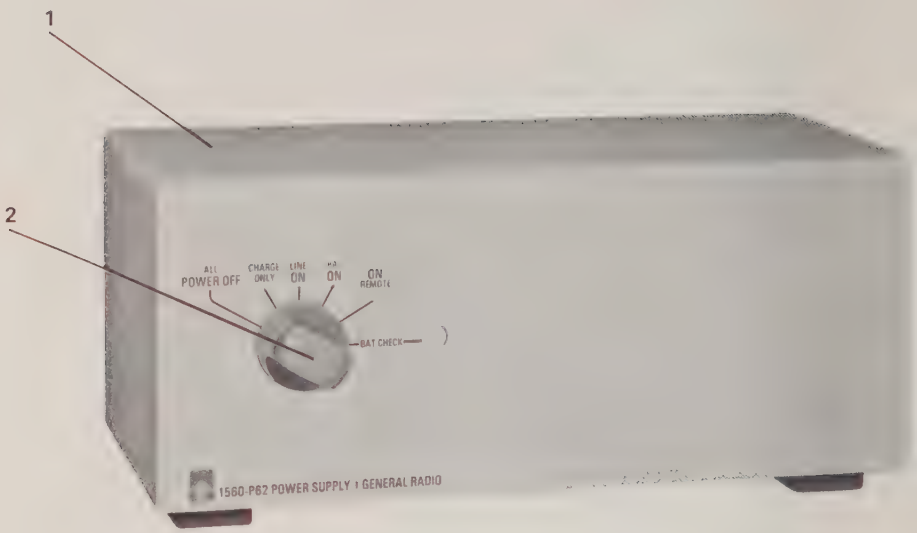


Figure 5-5. Mechanical parts — front view.

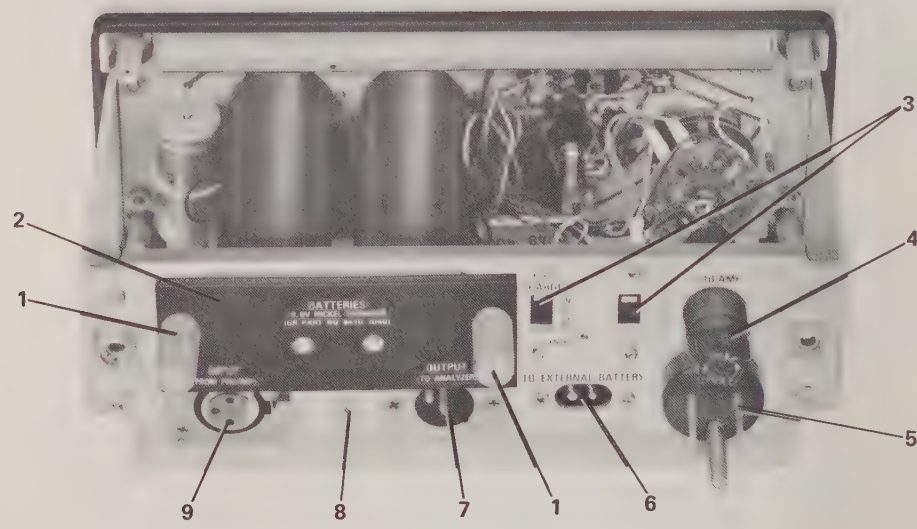
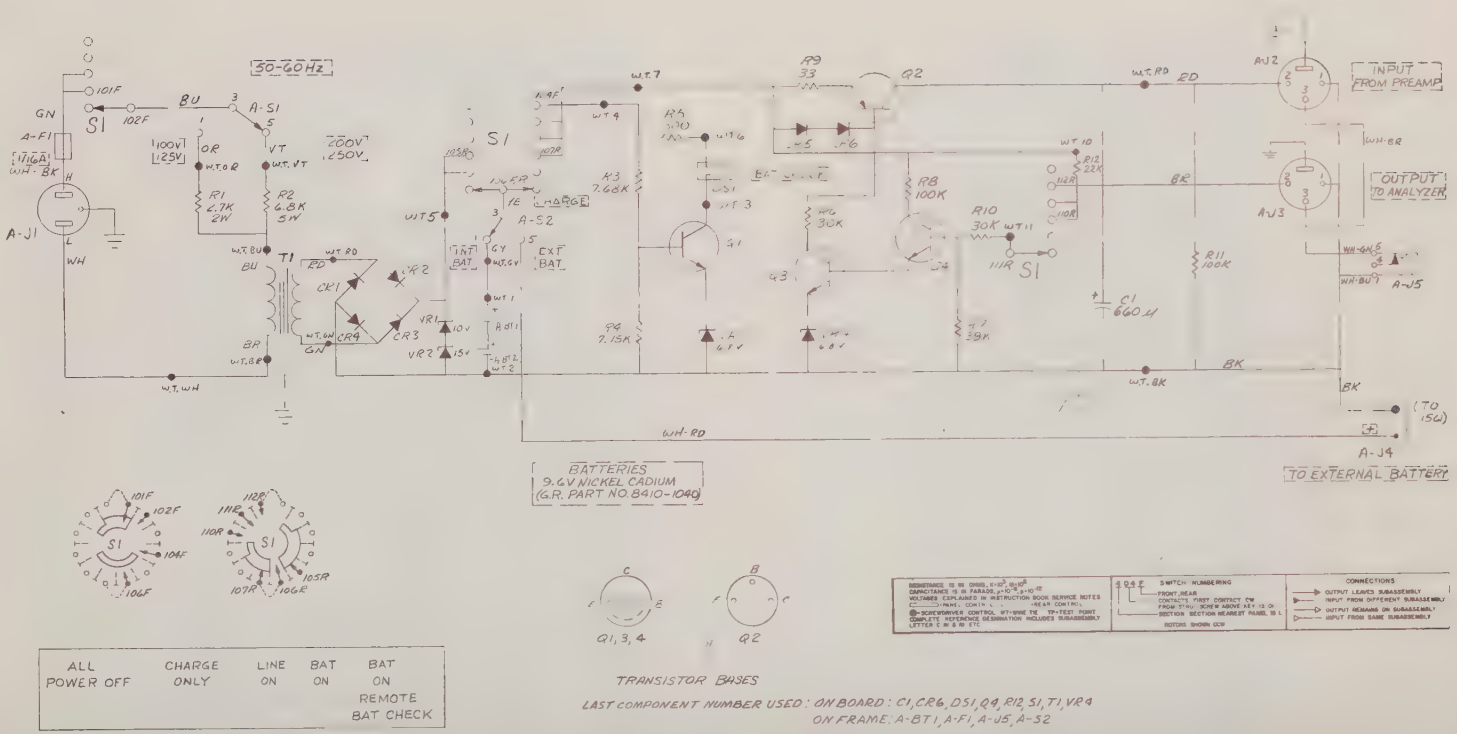


Figure 5-6. Mechanical parts — rear view.

ELECTRICAL PARTS LIST

Ref Des	Description	GR Part No.	Fed Mfg Code	Mfg Part No.	Fed Stock No.
BATTERIES					
A-B1 and A-B2		8410-1040	09823	CD25	
CAPACITORS					
C1	Electrolytic, 660 µF, +150-10%,25 V	4450-6125	37942	TT, 660 µF, +150-10%	
CONNECTORS					
A-J1	Power Plug	4240-0600	24655	4240-0600	5935-816-0254
A-J2	Multiple Socket	4230-2600	82389	D3F	
A-J3	Multiple Plug	4220-3100	71468	XLR-3-32	
A-J4	Plug Asm.	1561-2040	24655	1561-2040	
DIODES					
CR1 thru CR4	Type 1N3253	6081-1001	79089	1N3253	5961-811-8372
CR5 and CR6	Type 1N4442	6082-1009	24446	1N4442	5961-929-9967
VR1	Type 1N758A	6083-1012	07910	1N758A	
VR2	Type 1N965B	6083-1015	07910	1N965B	
VR3 and VR4	Type 1N957B	6083-1009	07910	1N957B	
FUSES					
A-F1	Cabinet Gasket	5331-3086	71400	MDL, .062 Amp	
LAMPS					
DS1	5600-0314	71744	#344	6210-082-0583	
RESISTORS					
R1	2.7 kΩ, ±5%, 2 W	6120-2275	01121	HB, 2.7 kΩ, ±5%	
R2	Pwr. Wire wound, 6.8 kΩ, ±5%, 5 W	6660-2685	80183	246E, 6.8 kΩ, ±5%	
R3	Comp., 7.68 kΩ, ±1%, 1/8 W	6250-1768	75042	CEA, 7.68 kΩ, ±1%	5905-978-8817
R4	Film, 7.15 kΩ, ±1%, 1/8 W	6250-1715	75042	CEA, 7.15 kΩ, ±1%	5905-815-3793
R5	Comp., 300 Ω, ±5%, 1/4 W	6099-1305	75042	BTS, 300 Ω, ±5%	5905-279-5481
R6	Comp., 30 kΩ, ±5%, 1/4 W	6099-3305	75042	BTS, 30 kΩ, ±5%	5905-803-2908
R7	Comp., 39 kΩ, ±5% 1/4 W	6099-3395	75042	BTS, 39 kΩ, ±5%	5905-686-3358
R8	Comp., 100 kΩ, ±5%, 1/4 W	6099-4105	75042	BTS, 100 kΩ, ±5%	5905-686-3129
R9	Comp., 33 Ω, ±5%, 1/4 W	6099-0335	75042	BTS, 33 Ω, ±5%	
R10	Comp., 30 Ω, ±5%, 1/4 W	6099-3305	75042	BTS, 30 kΩ, ±5%	5905-803-2908
R11	Comp., 100 kΩ, ±5%, 1/4 W	6099-4105	75042	BTS, 100 kΩ, ±5%	5905-686-3129
R12	Comp., 22 kΩ, ±5%, 1/4 W	6099-3225	75042	BTS, 22 kΩ, ±5%	5905-687-0002
SWITCHES					
A-S1 and A-S2	Slide	7910-0832	82389	11A-1118	
S1	Rotary Wafer	7890-5341	24655	7890-5341	
TRANSFORMERS					
T1		0748-4000	24655	0748-4000	
TRANSISTORS					
Q1	Type 2N3414	8210-1047	24454	2N3414	5961-989-2749
Q2	Type 2N3638	8210-1096	07263	2N3638	5961-912-9008
Q3 and Q4	Type 2N3414	8210-1047	24454	2N3414	5961-989-2749



ALL POWER OFF	CHARGE ONLY	LINE ON	BAT ON	BAT ON REMOTE BAT CHECK

Figure 5-7. Schematic circuit diagram of the 1560-P62 Power Supply.

Type 1972-9600 Preamplifier/Adaptor
Section 6

6.1 GENERAL 6-1
6.2 INSTALLATION 6-1
6.3 NOISE 6-3
6.4 SERVICE AND MAINTENANCE 6-4

6.1 GENERAL.

An inexpensive interface between a GR ceramic microphone and the measuring instrument is the 1972-9600 Preamplifier/Adaptor (Figure 6-1). This simple, easy-to-use preamplifier is designed to satisfy less-demanding requirements than those met by the 1560-P42 Preamplifier. It has reduced output voltage and current capabilities, offers only unity gain, and does not supply the polarizing voltage required to operate condenser microphones. In effect, the 1972-9600 serves as an impedance converter for ceramic microphones and vibration pickups. It provides a nominal input impedance of 1 GΩ in parallel with less than 3 pF. It has an output impedance of approximately 10 Ω. The schematic diagram is given in Figure 6-4.

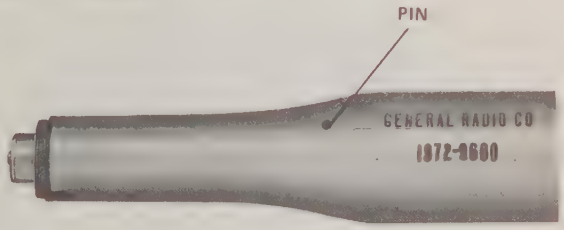


Figure 6-1. Type 1972-9600 Preamplifier/Adaptor.

6.2 INSTALLATION.

6.2.1 Power.

The Preamplifier is powered through the 3-wire (plus shield) output cable from the analyzing instrument or power supply. Table 1-2 lists the GR instruments that can provide the necessary power for the Preamplifier. The 1560-P62 Power Supply is also available to supply this power (refer to Section 5). With the 1972-9600 Preamplifier, the current is limited to 4 mA. Therefore, with the output stage operating class A, the average supply current drawn is the measured dc supply current, regardless of the load.

6.2.2 Mounting.

The 1560-9580 Tripod is recommended for mounting the 1972-9600 Preamplifier. Refer to para. 1.3.5 for a discussion of the use of this Tripod.

6.2.3 Connections.

The Preamplifier is terminated in a .460-60 male screw thread at the input and a male Switchcraft type A3 connector at the output. Thus, it mates directly with the GR ceramic microphones (1/2-in., 1972-9601 and 1-in., 1560-9570). The 1560-2131 ceramic cartridge can be adapted to the Preamplifier by using a 1560-9581 adaptor. Vibration pickups require a 1560-9669 adaptor.

When the Preamplifier is used with a microphone, its output can be connected directly to the input of the analyzing instrument. However, to reduce acoustical reflections from and diffractions around the body of the analyzer, a short length of cable should be used between preamplifier and analyzer. As much as 50 ft. of cable can be used before signal loss or distortion occurs. Refer to Figure 4-2 for permissible frequency limits of available current versus cable length.

If the Preamplifier/Adaptor is to be used as an adaptor (i.e., the prongs are not used) with a sound-level meter that uses the microphone-plus-cable capacitance as part of the weighting network (e.g., the GR 1565), the use of an extension cable will change the weighting characteristics. To compensate for this, a capacitor (C, Figure 6-3) must be added from high to ground (WT2 to pin 3) of the Preamplifier. Also, cable losses will cause the meter to read low by an amount that varies with the cable length. Figure 6-2 shows the value of the compensating capacitor for cable capacitances between 150 and 1500 pF and the loss to be added to the reading of the sound-level meter. This is often a convenient means of extending the upper sound-pressure range of the sound-level meter.

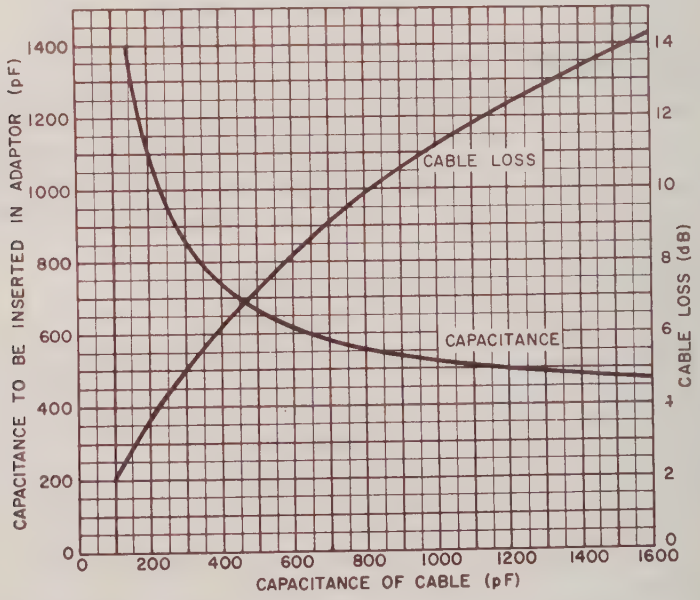


Figure 6-2. Compensation required for the capacitance of various extension cables and the corresponding cable loss.

6.2.4 Internal Bypass.

To use the Preamplifier/Adaptor as an adaptor only, the output lead can be connected directly to the input by means of a jumper. This will also allow the operator to realize fully the high-level capabilities of the ceramic microphones without distortion. No change in frequency response is encountered, but a flat loss occurs due to the capacitance loading of the cable. The procedure for bypassing is as follows:

a. Remove the circuitry (on board P/N 1933-4795) from the housing. To do this, push out the pin through the housing (see Figure 6-1) and slide the circuitry out the INPUT end. The output connector (P/N 1972-2000) will remain in the housing.

b. Carefully unsolder and remove the coupling capacitors, C1 and C2 (see Figure 6-3).

c. Disconnect the power wire (B+) at pin 2.

d. Solder an insulated wire from the input terminal (WT1, Figure 6-3) to the output terminal (pin 4).

e. Slide the circuitry into the housing until the four leads are properly inserted in the output connector. The circuitry is keyed to prevent incorrect insertion. Replace the pin removed in step a.

f. Place the microphone on the Preamplifier/Adaptor and use the 1562 Calibrator and the 1551, 1561, or 1933 Sound-Level Meter to check the alterations. Use a short connecting cable to the sound-level meter.

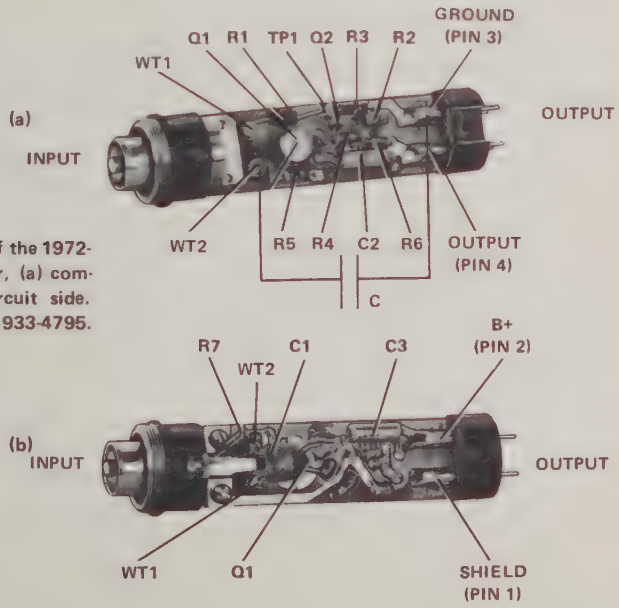


Figure 6-3. Interior views of the 1972-9600 Preamplifier/Adaptor, (a) component side, and (b) circuit side. Complete board is P/N 1933-4795.

6.3 NOISE.

The input noise of the 1972-9600 is similar to that of the 1560-P42, except that, with the former, the low-frequency noise is reduced because the protection diodes and "bootstrapping" circuit have been omitted. For high-capacitance microphones, the

1/3-octave noise curves for the 1560-P42 (Figure 4-12) are representative of the noise curves for the 1972-9600, except in the 20-100 Hz region, where the latter are several dB lower.

6.4 SERVICE AND MAINTENANCE.

6.4.1 GR Field Service.

The 1972-9600 Preamplifier/Adaptor is covered by the two-year warranty stated at the front of this manual.

The two-year warranty attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial, ID, and type numbers of the instrument.

6.4.2 Instrument Return.

Before returning an instrument to General Radio for service, please contact our Service Department or nearest District Office requesting a "Returned Material" number. Use of this number will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

6.4.3 Operational Test.

To remove the Preamplifier/Adaptor from its housing, follow the procedure given under "Internal Bypass," para. 6.2.4, above. Re-install the circuitry by reversing this procedure.

A simple dc test will indicate whether or not the Preamplifier is operating:

a. With the circuitry removed from its housing, resolder the output connection.

b. Apply power (15 V dc) to pin 2 of the output connector.

c. The voltage at the FET (Q1) source should be half the supply voltage plus a few tenths of a volt, as shown in Table 6-1. If it is not, the FET or Q2 or a related component is probably defective. Do not measure the gate voltage on Q1 (high impedance). The voltage at TP1, Figure 6-4, should be half of the supply voltage.

Table 6-1

TRANSISTOR VOLTAGES

		(With 15-V Supply)
Q1	D	14.4
	S	7.8
	G	—
Q2	E	15.0
	B	14.4
	C	7.8

1972-9600 PREAMPLIFIER/ADAPTOR

ELECTRICAL PARTS LIST

Ref Des	Description	GR Part No.	Fed Mfg Code	Mfg Part No
CAPACITORS				
C1	Ceramic, .001 μF ±10% 200 V	4400-6440	72982	8121-026-X5RO-102K
C2	Tantalum, 6.8 μF ±20% 15 V	4450-6401	56289	163-D
C3	Tantalum, 1.0 μF ±20% 35 V	4450-6400	56289	162-D
RESISTORS				
R1	Comp., 1 GΩ ±20%, 1/8 W	6098-8108	01121	BB, 1 G ±20%
R2	Comp., 100 KΩ ±5% 1/8 W	6098-4105	01121	BB, 100 K ±5%
R3	Comp., 100 KΩ ±5% 1/8 W	6098-4105	01121	BB, 100 K ±5%
R4	Comp., 12 KΩ ±5% 1/8 W	6098-3125	01121	BB, 12 K ±5%
	Comp., 6.2 KΩ ±5% 1/8 W	6098-2625	01121	BB, 6.2 K ±5%
	Comp., 3.3 KΩ ±5% 1/8 W	6098-2335	01121	BB, 3.3 K ±5%
R5	Comp., 4.7 KΩ ±5% 1/8 W	6098-2475	01121	BB, 4.7 K ±5%
R6	Comp., 100 KΩ ±5% 1/8 W	6098-4105	01121	BB, 100 K ±5%
R7	Comp., 3.0 KΩ ±5% 1/8 W	6098-2305	01121	BB, 3.0 K ±5%
TRANSISTORS				
Q1	Type 2N3457	8210-1082	94589	2N3457
Q2	Type D30A3	8210-1204	24454	D30A3

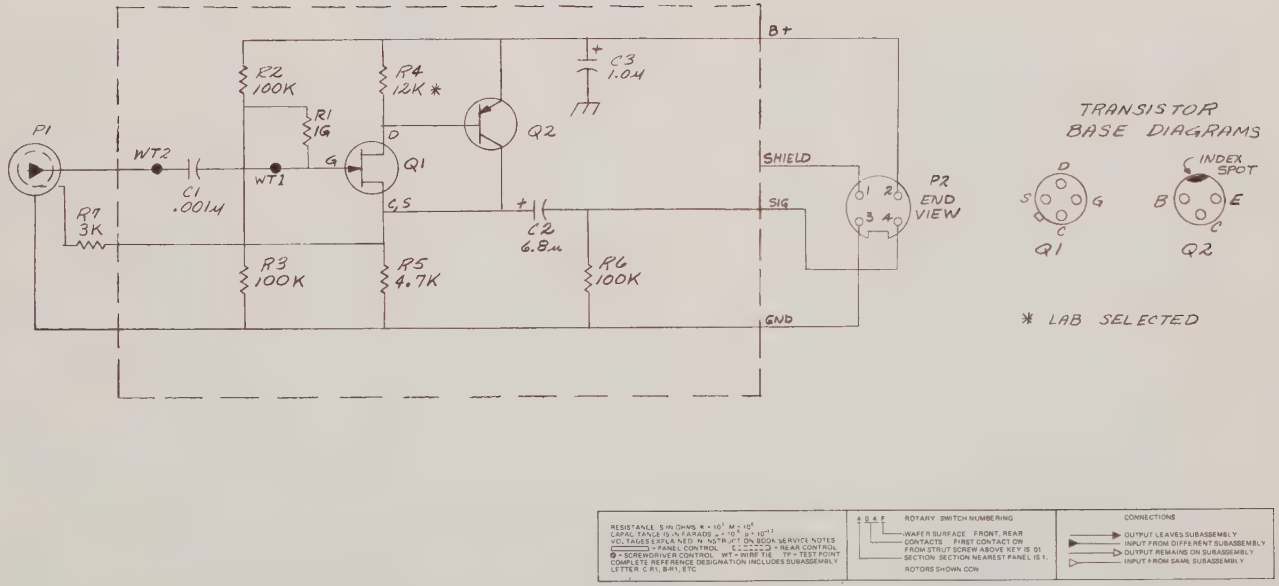


Figure 6-4. Schematic circuit diagram for the 1972-9600 Preamplifier/Adaptor.

FEDERAL MANUFACTURER'S CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) as supplemented through August, 1968.

Code	Manufacturer
00192	Jones Mfg. Co, Chicago, Illinois
00194	Walsco Electronics Corp, L.A., Calif.
00434	Schweber Electronics, Westburg, L.I., N.Y.
00656	Aerovox Corp, New Bedford, Mass.
01009	Alden Products Co, Brockton, Mass.
01121	Allen-Bradley, Co, Milwaukee, Wisc.
01236	Leeds Radio Company, N.Y.
01255	Litton Industries Inc, Beverly Hills, Calif.
01295	Texas Instruments, Inc, Dallas, Texas
02114	Ferroxcube Corp, Saugerties, N.Y. 12477
02606	Fenwal Lab Inc, Morton Grove, Ill.
02660	Amphenol Electron Corp, Broadview, Ill.
02768	Fastex, Des Plaines, Ill. 60016
03042	Carter Ink Co., Camb. Mass. 02142
03508	G.E. Semicon Prod, Syracuse, N.Y. 13201
03636	Grayburne, Yonkers, N.Y. 10701
03888	Pyrofilm Resistor Co, Cedar Knolls, N.J.
03911	Clairex Corp, New York, N.Y. 10001
04009	Arrow-Hart & Hegeman, Hart., Conn. 06106
04643	Digitronics Corp., Albertson, N.Y. 11507
04713	Motorola, Phoenix, Ariz. 85008
05170	Engr'd Electronics, Santa Ana, Calif. 92702
05624	Barber-Colman Co, Rockford, Ill. 61101
05748	Barnes Mfg. Co., Mansfield, O. 44901
05820	Wakefield Eng, Inc, Wakefield, Mass. 01880
06743	Clevite Corp., Cleveland, O. 44110
07126	Digitron Co, Pasadena, Calif.
07127	Eagle Signal (E.W. Bliss Co.), Baraboo, Wisc.
07261	Avnet Corp, Culver City, Calif. 90230
07263	Fairchild Camera, Mountain View, Calif.
07387	Birtcher Corp, No. Los Angeles, Calif.
07595	Amer Semicond, Arlington Hts, Ill. 60004
07828	Bodine Corp, Bridgeport, Conn. 06605
07829	Bodine Electric Co, Chicago, Ill. 60618
07910	Cont Device Corp, Hawthorne, Calif.
07983	State Labs Inc, N.Y., N.Y. 10003
07999	Borg Inst., Delavan, Wisc. 53115
08730	Vemaline Prod Co., Franklin Lakes, N.J.
09213	G.E. Semiconductor, Buffalo, N.Y.
09408	Star-Tronics Inc, Georgetown, Mass. 01830
09823	Burgess Battery Co, Freeport, Ill.
09922	Burndy Corp, Norwalk, Conn. 06852
11236	C.T.S. of Berne, Inc, Berne, Ind. 46711
11599	Chandler Evans Corp, W. Hartford, Conn.
12040	National Semiconductor, Danbury, Conn.
12498	Crystalonics, Cambridge, Mass. 02140
12672	RCA, Woodbridge, N.J.
12697	Clarostat Mfg Co, Inc, Dover, N.H. 03820
12954	Dickson Electronics, Scottsdale, Ariz.
13327	Solitron Devices, Tappan, N.Y. 10983
14433	ITT Semiconductors, W. Palm Beach, Fla.
14655	Cornell-Dubilier Electric Co., Newark, N.J.
14674	Corning Glass Works, Corning, N.Y.
14936	General Instrument Corp, Hicksville, N.Y.
15116	Microdot Magnetics Inc, Los Angeles, Calif.
15238	ITT, Semiconductor Div, Lawrence, Mass.
15905	Cutler-Hammer Inc, Milwaukee, Wisc. 53233
16037	Spruce Pine Mica Co, Spruce Pine, N.C.
16636	Indiana General Corp, Oglesby, Ill. 61348
17771	Singer Co, Diehl Div, Somerville, N.J.
18736	Voltronics Corp, Hanover, N.J. 07936
19396	Illinois Tool Works, Pakton Div, Chicago, Ill.
19048	Computer Diode Corp, S. Fairlawn, N.J. 07410
19617	Cabtron Corp., Chicago, Ill. 60622
19644	LRC Electronics, Horseheads, N.Y.
19701	Electra Mfg Co, Independence, Kansas 67301
20354	KMC Semiconductor Corp., Long Valley, N.J. 07853
21335	Fafnir Bearing Co, New Briton, Conn.
22753	UID Electronics Corp, Hollywood, Fla.
23342	Avnet Electronics Corp, Franklin Park, Ill.
24446	G.E., Schenectady, N.Y. 12305
24454	G.E., Electronics Comp, Syracuse, N.Y.
24455	G.E. (Lamp Div.), Nela Park, Cleveland, Ohio
24655	General Radio Co, W. Concord, Mass. 01781
25806	American Zettlet Inc, Costa Mesa, Calif.
25520	Hayman Mfg Co, Kenilworth, N.J.
25959	Hoffman Electronics Corp, El Monte, Calif.
26546	Beckman Instruments Inc, Cedar Grove, N.J. 07009
26874	I.B.M., Armonk, New York
27001	Jensen Mfg. Co, Chicago, Ill. 60638
27173	G.E. Comp, Owensboro, Ky. 42301
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34848	Ward Leonard Electric Co, Mt. Vernon, N.Y.
34853	Westinghouse (Lamp Div), Bloomfield, N.J.
34864	Weston Instruments, Newark, N.J.
34882	Atlantic-India Rubber, Chicago, Ill. 60607
34883	Amperite Co, Union City, N.J. 07087
34884	Belden Mfg Co, Chicago, Ill. 60644
34885	Bronson, Homer D, Co, Beacon Falls, Conn.
34886	Cambridge Thermionic Corp, Camb. Mass. 02138
34887	Canfield, H.O. Co, Clifton Forge, Va. 24422
34888	Bussman (McGraw Eidson), St. Louis, Mo.
34889	ITT Cannon Elec, L.A., Calif. 90031
34890	Centralab, Inc, Milwaukee, Wisc. 53212
34891	Continental Carbon Co, Inc, New York, N.Y.
34892	Crescent Box Corp, E. Phila, Penn. 19134
34893	Coto Coil Co Inc, Providence, R.I.
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34896	Darnell Corp, Ltd, Downey, Calif. 90241
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34900	General Instr Corp, Newark, N.J. 07104
34901	Drake Mfg Co, Chicago, Ill. 60656
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34930	Ray-O-Vac Co, Madison, Wisc.
34931	TRW, Electronic Comp, Camden, N.J. 08103
34932	General Instruments Corp, Brooklyn, N.Y.
34933	Shakeproof (III. Tool Works), Elgin, Ill. 60120
34934	Sigma Instruments Inc, S. Braintree, Mass.
34935	Stackpole Carbon Co, St. Marys, Penn.
34936	Tinnerman Products, Inc, Cleveland, Ohio
34937	RCA, Rec Tube & Semicond, Harrison, N.J.
34938	Wiremold Co, Hartford, Conn. 06110
34939	Zierick Mfg Co, New Rochelle, N.Y.
34940	Tektronix Inc, Beaverton, Ore. 97005
34941	Prestole Fastener, Toledo, Ohio
34942	Vickers Inc, St. Louis, Mo.
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34978	Lehigh Metal Prods, Cambridge, Mass. 02140
34979	TA Mfg Corp, Los Angeles, Calif.
34980	Precision Metal Prods, Stoneham, Mass. 02180
34981	RCA (Elect. Comp & Dev), Harrison, N.J.
34982	REC Corp, New Rochelle, N.Y. 10801
34983	Cont Electronics Corp, Brooklyn, N.Y. 11222
34984	Cutler-Hammer Inc, Lincoln, Ill.
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